

TeamFour/Saur A R C H I T E C T S

Wind P/V Package

ARRA Mechanical Project

Robert A. Young Federal Building

1222 Spruce Street
Saint Louis, MO 63103

Owner:

GENERAL SERVICES ADMINISTRATION

Heartland Region
Public Buildings Service (6PET)
1500 East Bannister Road
Kansas City, Missouri 64131-3088

Contract Number: GS06P04GYD0003
Project Number: IMO00090
Work Order Number: 68

100% Documents

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Team Four Project Number: 29029.00
July 1, 2010

Scope Document

TeamFour/Saur – Architects

William Tao & Associates – Engineers

Final Submittal – 07/01/2010

MECH BASE – WIND/PV PACKAGE

Wind/PV Design

The intent of this project is to install a wind and photovoltaic power system that is grid-tied with the electrical utility power for the building. The power generated by the wind and photovoltaic systems will provide only a small portion of the buildings power consumption requirements. The electrical utility will remain the primary source of power to the building with the wind and photovoltaic systems supplementing and therefore reducing the electrical utility power demand and consumption. During a utility power outage, the utility company requires that any on-site power generation system shall not be capable of delivering power back onto the utility power grid. AmerenUE will require a review of the construction documents and installation.

The existing building has several constraints that Limit the locations and areas where the wind and photovoltaic systems can be installed. Due to the amount of shade from the rooftop penthouse on the north and west portion of the main building roof, the photovoltaic systems will be installed on the south and east portion of the main building roof and on the penthouse roof. The wind and photovoltaic system will be installed to allow access to existing roof drains, vent pipes, mechanical equipment and window wash anchoring system. This includes a 10' clearance from roof edges as required by the international Building Code, a 6' clearance in front of the widow wash anchoring rail system as recommended by window washing company for safety tie-off, a 5' clearance around roof-top penthouses, and 4' clearance around mechanical equipment for maintenance access. Additional 5' access isles will be provided as required for access to and from roof perimeter and window wash anchoring system

The base bid scope includes the installation of a flat self-ballast interlocking photovoltaic tile system on the flat portions of the main building roof between the window wash anchoring systems and the roof perimeter as required to allow the window wash support cables to be routed over this system. The tiles will be installed to maintain the 6' clearance in front of the window wash anchoring rail system and the 10' clearance from the roof edge. The roof tiles will be located as required to allow access to existing roof drains, vents and exhaust fans. Based on minimum reinforcement required for structural slabs at the time the building was constructed, the roof slab can safely support an additional 10 pounds per square foot. The new solar system shall not impose a load

greater than this amount. This photovoltaic tile system will provide a maximum output rating of approximately 140KW.

Option bid E1 scope includes the installation of photovoltaic panels on a tilted, ballasted rack system on the portions of the main building roof that are not affected by the window washing equipment tie-offs. Photovoltaic panels installed on a tilted ballasted rack system provide greater efficiency than those in a flat system. The tilted system weighs more than the flat system and may require attachment to the building to prevent movement caused by wind gusts. Based on minimum reinforcement required for structural slabs at the time the building was constructed, the roof slab can safely support an additional 10 pounds per square foot. The new solar system shall not impose a load greater than this amount. This system will provide a maximum output rating of approximately 70KW.

Option bid E2 scope of work includes the installation of photovoltaic panels on a tilted ballasted rack system on the roofs of the electrical/equipment penthouses. The roofs of the prefabricated AHU enclosures do not have the capacity to support a tilted, ballasted rack system. Due to the limited space on (3) elevator/stair penthouses, photovoltaic panels will not be installed on these areas. The upper portion of the electrical/equipment penthouse between column lines 10 and 12 does not have the capacity to support a tilted, ballasted rack system and has therefore been eliminated from this bid. The remaining electrical/equipment penthouse roofs have a residual capacity of 13 pounds per square foot. The new solar system shall not impose a load greater than this amount. This system will provide a maximum output rating of approximately 15KW.

Option bid E3 scope of work includes the installation of vertical axis wind turbines. To maximize wind forces, wind turbines should be installed at the highest elevation possible. Each of the three elevator/stair penthouse roofs has sufficient capacity to support a vertical axis wind turbine with a structural cage. The concrete elevator/stair penthouse roof between column lines A and B and the northern portion of the elevator/stair penthouse roof between column lines 5 and 6 have a residual capacity of 96 pounds per square foot. The south elevator/stair penthouse roof between column lines E and F has a residual capacity of 22 pounds per square foot. Connections for the wind turbine on the elevator/stair penthouse between column lines 5 and 6 shall be attached directly to the steel joist supporting the roof. This system will provide a maximum output rating of approximately 6KW.

The wind and photovoltaic systems will be grid tied with the electrical utility service from the existing electrical building distribution system. Each wind and photovoltaic panel string will be connected to a separate string combiner box, meter and inverter for a system located in the main electrical room penthouse. Each wind and photovoltaic system will be provided with a separate inverter for reliability and maintenance and be separately metered to monitor output and efficiency. A panelboard will be provided to collect the AC outputs of all the wind and photovoltaic system inverters. The panelboard will be connected to the existing electrical substation to parallel and supplement the existing utility power system. The inverter will convert the DC power generated by the wind and photovoltaic systems to AC power for connection to an electrical distribution system as required for paralleling and supplementing the existing utility electrical service with the new wind and photovoltaic systems. The string combiner boxes and inverters will be provided in the available space near the electrical distribution equipment in two of

the mechanical penthouses. Since this work will be performed on the roof and mechanical penthouses, it should have a very limited impact on the building tenants.

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SECTION 260000 - OPTIONS

PART 1 - GENERAL

1.1 REFERENCES

- A. All provisions of Division 01, GENERAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL REQUIREMENTS

- A. Bids submitted by Contractor shall state the amount to be added to the base bid for the following option(s) if accepted.

1.3 SCOPE OF WORK

- A. Bidder shall make certain that he understands the scope of each option and shall evaluate all resulting additions, deletions and alterations to all affected work and shall include the cost of all such factors including all overhead and profit in his proposal for each alternate.

PART 2 - PRODUCTS

2.1 OPTIONS

- A. Proprietary differences between base bid products and option products are allowable; however; functions, ratings, safety devices, and other requirements of base bid equipment, device or system shall be included in each option bid.
 - 1. Refer to description of Options in Division 01, GENERAL REQUIREMENTS.
 - 2. Option E1: Indicate the contract amount to be added to the base bid for providing ballasted rack photovoltaic system at a 10 degree tilt on main roof in addition to specified photovoltaic system.
 - 3. Option E2: Indicate the contract amount to be added to the base bid for providing ballasted rack photovoltaic system at a 10 degree tilt on electrical penthouse roof in addition to specified photovoltaic system.
 - 4. Option E3: Indicate the contract amount to be added to the base bid for providing vertical axis wind turbine system on elevator/stair penthouse roofs in addition to the specified photovoltaic system.

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PART 3 - EXECUTION

3.1 MANUFACTURER'S STANDARDS

- A. Products or systems, as described in Division 01 Options shall be installed according to manufacturer's recommendations and related auxiliary components required by specific manufacturer shall be provided.

3.2 RELATED WORK

- A. Other work affected by these options shall be included in Contractor's bid as required to provide a coordinated fully operating equipment, device or system.

END OF SECTION 260000

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SECTION 260100 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.1 REFERENCES

- A. All provisions of GENERAL CONDITIONS, SUPPLEMENTARY CONDITIONS, SPECIAL CONDITIONS and Sections in Division 01, GENERAL REQUIREMENTS, govern work under this specification division.
- B. References to standards of organizations are made herein in accordance with the following abbreviations:

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ADA	Americans with Disabilities Act
ADAAG	Americans with Disabilities Act Accessibility Guideline
AEIC	Association of Edison Illuminating Companies
AIA	The American Institute of Architects
ANSI	American National Standards Institute Inc.
ASA	American Standards Association
ASHRAE	American Society of Heating, Refrigeration and Air Conditioning Engineers
ASTM	American Society for Testing and Materials
AWPA	American Wood Preservers Association
BMA	BACnet Manufacturer's Association
BOCA	Building Officials and Code Administrators International, Inc.
CBEMA	Computer and Business Equipment Manufacturers Association
CBM	Certified Ballast Manufacturers Association
CPD	Construction Products Directive (CE Mark)
EEI	Edison Electrical Institute
EGSA	Electrical Generating Systems Association
EIA	Electronic Industries Association
EPA	Environmental Protection Administration
ETL	Electrical Testing Laboratories Inc.
FAA	Federal Aviation Agency
FCC	Federal Communications Commission
FHWA	Federal Highways Administration
FIA	Factory Insurance Association
FM	Factory Mutual Research Corp.
IAEI	International Association of Electrical Inspectors
ICBO	International Conference of Building Officials (UBC Sponsors)
ICEA	Insulated Cable Engineers Association
IEC	International Electro-Technical Commission
IEEE	Institute of Electrical and Electronics Engineers

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IES	Illuminating Engineering Society
ISO	International Standard Organization
LEED	Leadership in Energy and Environmental Design
LPI	Lightning Protection Institute
MFMA	Metal Framing Manufacturers Association
NAECA	National Appliance Energy Conservation Act 1988
NEC	National Electrical Code (NFPA 70)
NEMA	National Electrical Manufacturer's Association
NFAC	National Fire Alarm Code (NFPA 72)
NFPA	National Fire Protection Association
NESC	National Electric Safety Code
NICET	National Institute of Certified Engineering Technicians
OSHA	Occupational Safety and Health Administration
RUS	Rural Utility Services
TIA	Telecommunications Industry Association
SBC	Standard Building Code
UL	Underwriters Laboratories, Inc.
WTA	William Tao & Associates, Inc.

- C. Work installed shall be in strict compliance with governing codes and regulations. Installation shall be in accordance with installation recommendations and details provided by product manufacturers unless exceeded in quality by these specifications. Work called for in the specifications or shown on the drawings that is deemed contrary to the code by the local authority having jurisdiction governing shall be brought to attention of Engineer prior to rough-in for clarification or revision.

1.2 GENERAL REQUIREMENTS

A. WTA Computer Aided Design (CAD) Drawings in Electronic Format:

1. Computer Aided Design (CAD) drawings in electronic format when provided under this contract shall be for the convenience of the recipient only. The CAD drawings were prepared as William Tao & Associates, Inc. internal working documents. Depending on how the drawings are utilized and reassembled the resulting CAD drawings may be incomplete, contain inaccuracies or be in part obsolete. Therefore, William Tao & Associates, Inc. makes no representation as to its completeness, currency or accuracy.
2. The user is advised that any translation of CAD drawings from one computer system or environment to another can and often does result in the loss of important data. This loss can include but may not be limited to: portions of text and dimensions - The existence, location or scale of symbols or other elements of graphics - The internal structure of the data including layers and data attributes - The style or weight of lines. William Tao & Associates, Inc. makes no representations as to the usability of this CAD data on any system.
3. The user is further warned that, while all digital CAD data appears to be extremely accurate, this apparent accuracy is an artifact of the techniques used to generate it and is in no way intended to imply actual accuracy. The user of this data takes full

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responsibility for the accuracy and correctness of all measurements, areas, inventories, etc. extracted from this data either manually or with the use of a computer.

B. First-Named Manufacturer:

1. First-named manufacturer's device, equipment or system has been used in specifications and drawings to meet the job requirements and to determine the space and dimensional requirements. Verify that devices, equipment, systems or products by other than the first-named manufacturer used as basis for proposal will meet the job requirements and will fit the allocated space.
2. Listing of a manufacturer as acceptable does not in any way relieve the Contractor from the responsibility for providing a device, equipment or system that meets the requirements of the specifications.
3. No extra cost will be allowed due to effect on other trades when bid is based on products other than first-named manufacturer. Contractor shall be responsible for coordination required for the use of substituted devices, equipment, systems, or products by other than the first-named manufacturer.

C. Drawing Details: Since the installation of devices, equipment and systems may vary by each manufacturer and the "approved manufacturer" for the job was unknown at the time the drawing details were made, the details shown on the drawings are to be accepted by the Contractor as general in nature and are not to be used for their installation. Contractor shall obtain from the "approved manufacturer" of the devices, equipment or systems detailed installation drawings for their proper installation.

D. Deviations from Specified Devices, Equipment or System: While it is recognized that devices, equipment or systems by other than the first-named manufacturer may not be exactly identical, the Contractor shall verify and provide devices, equipment, systems, or products that meet the specified job requirements. All deviations of devices, equipment, systems, or products from the first-named manufacturer shall be clearly noted on shop drawing submittal or by cover letter. Engineer reserves the right to reject all devices, equipment or systems he feels does not meet the specified job requirements.

E. Submission of shop drawings will be considered as indicating that space requirements have been reviewed and that submitted equipment will fit space allocated with due concern given to access required for maintenance purposes.

F. Contract drawings and specifications are complementary and what is called for by one shall be as binding as if called for by both.

G. Contractor shall furnish all labor and material required to complete installation including accessories, fittings, auxiliaries, and components required for proper performance of systems.

H. "Provide" as called for in the specifications or on the drawings shall mean, "furnish and install."

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I. Location of Equipment and Devices:

1. Locations of the electrical equipment and devices shown are approximate. Determine the exact location of the equipment and devices by checking the drawings, field measurements or the approved shop drawings.
2. Relocate equipment or devices when directed by Engineer without cost, providing equipment has not been installed and the new location is not greater than 10 ft. from the location shown.

J. Do not scale drawings. Refer to Structural Drawings for new and existing building construction, dimensions and finishes in order to provide proper rough-in and installation of work.

K. Quality Control:

1. Exposed Work in Finished Spaces: Install electrical devices and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed.
2. Equipment Access: Install electrical devices and equipment to facilitate servicing, maintenance and repair or replacement. As much as practical, connect equipment for ease of disconnecting with minimum of interference with other installations.
3. Cleanliness: Contractor shall keep debris and dirt from around, on top of and the inside of all electrical equipment he provides during construction.

1.3 SCOPE OF WORK

A. Provide labor, material, mounting hardware, terminations, tools, transportation, services, and equipment necessary to provide complete and operating systems for work specified in Division 26. See individual sections for Scope of Work and Section 010100 and Electrical Work (GMP) conditions. Following general items shall be included as part of required work.

1. Panelboards (circuit breaker and fusible switch)
2. Wind/PV systems
3. Disconnect switches
4. Fuses
5. Conduits
6. Low-voltage conductors and terminations
7. Vibration and seismic control requirements
8. Grounding
9. All miscellaneous wiring, conduit, accessories and devices to result in a complete electrical system.

B. Provide commissioning as specified in Section 171000 - COMMISSIONING REQUIREMENTS and Division 01, GENERAL COMMISSIONING REQUIREMENTS.

C. See Division 01, LEED REQUIREMENTS, for requirements including, but not limited to construction IAQ management plan.

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1.4 DESCRIPTION OF SYSTEMS

- A. See individual sections of Division 26 for general description of required electrical systems, equipment, devices and products.

1.5 SUBSTITUTIONS

- A. See Division 01, GENERAL CONDITIONS.
- B. Reference related Division 26 sections of specifications for additional requirements.
- C. Submit to Engineer a typed list of substitutes proposed to be used in lieu of the device, equipment or system named in specifications or drawings with a request for approval of the proposed substitutes. List and written requests with detailed information shall be delivered to office of Engineer not later than 10 days prior to bid due date to be considered for approval. Submittal shall include following:
 - 1. Specific device, equipment or system proposed for substitution giving manufacturer, catalog and model number.
 - 2. Performance and dimensional data necessary for comparison of proposed substitute with equipment or material specified.
- D. When the Contractor does not provide the written request for substitutions, the Contractor shall be required to provide one of the listed manufacturers in the specifications or on the drawings.
- E. Samples shall be provided when requested by Engineer. Samples shall be delivered to office of Engineer with transportation charges prepaid. Supplier will be notified and shall cause sample to be removed from office of Engineer in unpacked condition at completion of Engineer's examination of product. Samples not removed after 30 days will be discarded.
- F. Addenda for proposed substitutes that are found to be acceptable will be issued by Engineer. Engineer reserves right to reject substitutes which are inferior in quality, capacity or design, or which adversely affect overall concept. Decision of Engineer shall be final.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Division 01, LEED REQUIREMENTS for preliminary submittal, progress reports and submittal documentation requirements.
- B. Shop drawings shall be submitted in accordance with Division 01, SHOP DRAWINGS and related articles of GENERAL CONDITIONS and with the requirements of this article.
- C. See article entitled Submittal Summary and detailed shop drawing requirements in other sections of Divisions 26. Submittal transmittal shall reference specification section and description of equipment. Submittals shall be clearly scheduled and marked as to which model number, quantity and type is being submitted. Copies of catalog cut sheets are not sufficient

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unless clearly defined project specific information is marked. Shop drawings that are resubmitted shall be noted as resubmittals and shall be given same WTA log number, as original submittal, suffixed by A or B as applicable.

- D. Shop drawings shall be phased and submitted in a sequence, which allows adequate time for Engineer review. Submittal of large numbers of shop drawings simultaneously is discouraged and may result in time for review, which exceeds the normal 2 week commitment for return. Any effect on construction schedule due to untimely submittal of shop drawings shall be the responsibility of the Contractor. Contractor shall submit Electrical Submittal Summary within 2 weeks of being awarded the contract.
- E. Only one original reproducible transparency shall be furnished when shop drawings are in form of custom-prepared drawings, schedules or modified printed literature. Drawing shall have blank space for use by Engineer and Contractor for recording disposition of material. Engineer will make their own file copies. Reproducible original will be returned to Contractor who shall make copies of corrected drawings for distribution as required.
- F. Shop drawings and product data of standard cataloged products shall be submitted with applicable data that meet the job requirements. Submittals that include information on multiple devices or equipment are acceptable only when items applicable to the job are identified with arrows, check marks or other call outs. Schedules shall be submitted in reproducible form as stated above. Schedules shall be not less than double spaced to allow for corrections by Engineer. Manufacturer's printed literature, catalogs or bulletins covering equipment shall be submitted with schedules in quantity called for under Division 01, GENERAL CONDITIONS. Printed material shall also be included in Maintenance Manual.
- G. Deviations from Specified Devices, Equipment or System: While it is recognized that devices, equipment or systems by other than the first-named manufacturer may not be exactly identical, the Contractor shall verify and provide devices, equipment, systems, or products that meet the specified job requirements. All deviations of devices, equipment, systems, or products from the first-named manufacturer shall be clearly noted on shop drawing submittal or by cover letter. Engineer reserves the right to reject all devices, equipment or systems he feels does not meet the specified job requirements.
- H. Shop drawings are required for equipment, material and devices scheduled in Submittal Summary. Shop drawings of related equipment, devices and material shall be submitted at same time so Engineer can coordinate related components.
- I. Shop drawings larger than 8-1/2 inch x 11 inch shall be inserted into manila pocket secured in brochure in order that drawings may be individually removed. Bound foldout sheets are not acceptable.
- J. Incomplete submittals and submittals not in accordance with requirements of this article will be returned without action, and resubmittal will be required.

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- K. Corrections or modifications made by Engineer shall be deemed acceptable with no change in the contract amount unless written notice is received by the Engineer prior to the performance of the work affected by the corrections or modifications.
- L. Review and stamp shop drawings in accordance with requirements of GENERAL CONDITIONS prior to submittal to Engineer. Shop drawings without Contractor's stamp will be returned without checking.
- M. No material or equipment shall be released for manufacture or shipment without first obtaining the Engineer's approved shop drawings.
- N. When shop drawings are created from or incorporated with the Engineer's CAD drawings, the Contractor shall remove the Engineer's title block and reinsert the Contractor's title block. The new title block shall include the Contractor's name, address and telephone number, the project name and the name of the Engineer of record. Reference preceding GENERAL REQUIREMENTS Article 1.2 in this Section for the contents of the CAD drawings in electronic format provided by WTA.
- O. Submittal Summary: See SUBMITTAL SUMMARY at end of this specification section.

1.7 LIST OF MANUFACTURERS FOR MATERIAL AND EQUIPMENT

- A. Submit List of Material and Equipment within 2 calendar weeks after award of contract by Owner. Provide six (6) copies to Engineer for approval of the manufacturers of material and equipment proposed for project.
- B. Approval of the shop drawings will be subject to the submission of material and equipment by the manufacturers shown on this list.
- C. Provide the first-named manufacturer for material and equipment on project if the "List of Material and Equipment" is not received by the Engineer within the prescribed time limit, or if the specified equipment or material is not listed on the submitted list. Reference preceding GENERAL REQUIREMENTS article in this section for first-named manufacturer requirements.

1.8 MATERIALS AND WORKMANSHIP

- A. Material and equipment required under this contract shall be new unless otherwise specified. Workmanship shall be first class and be performed by persons qualified in respective trades.
- B. Material shall meet requirements of governing codes and regulations.
- C. Electrical material, equipment and systems, where applicable, shall be UL listed.

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1.9 CONTRACTOR'S SUPERVISION AND SUBCONTRACT WORK

- A. Work shall be under constant supervision of qualified superintendent or foreman.
- B. Submit name of major subcontractors to Engineer for approval prior to award of subcontract work. Engineer reserves right to approve or disapprove major subcontractors.
- C. Job superintendents or foremen shall not be changed without prior notice to and approval of Engineer in order to maintain proper coordination and continuity of branches of work.

1.10 COORDINATION

- A. Coordinate work to eliminate interferences. Interferences due to lack of coordination shall be corrected to provide proper clearance and access with costs borne by Contractor. Electrical equipment shall not be hung from piping or ductwork or from hangers supporting piping or ductwork. Install conduit and boxes giving right-of-way where space is available to systems such as plumbing, drain and fire protection lines required to be installed at a specified slope.
- B. All electrical equipment, without exception, shall be installed with adequate space and working clearances as required by the NEC. In addition, clearances shall be maintained to allow for access, repairs and removal of equipment and devices. Protect installation of equipment or devices from being obstructed by other equipment, piping, etc. installed by other contractors on the project.
- C. Contractor shall prepare drawings for installation of equipment, devices and systems as required to coordinate work. Joint coordination drawings by Contractors shall be prepared as a joint effort to coordinate installation of work by the affected trades. These drawings are not to be submitted to the Engineer for approval.
- D. Permanent openings or knockout panels shall be provided to permit future service or replacement of system components, but not necessarily for entry or exit of entire assembled units. Coordinate equipment delivery with construction progress in order that installation may be made in orderly and safe manner.
- E. Contractor shall provide arrangements for hoisting equipment and assume related cost. Routes used by hoisting vehicles and vehicle parking shall be approved by Owner prior to their use.
- F. Building structure is designed for supporting equipment at its permanent location. Provide necessary shoring or other protection necessary for moving heavy equipment to permanent location.
- G. Contractor shall coordinate his equipment delivery with construction progress in order that installation may be made in an orderly and safe manner.

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1.11 SITE OBSERVATION

- A. Visit site prior to preparation of bid and determine conditions that affect execution of work.
- B. Locations and elevation of existing utilities, such as water piping, cables, and conduits are as exact as can be determined from available information and their accuracy cannot be guaranteed. Exact location of these services shall be verified by Contractor prior to installation of work. Existing services damaged due to operation of Contractor shall be repaired to satisfaction of Owner and Utility Company at Contractor's expense.
- C. Connections to or relocation of existing utility lines requiring temporary discontinuation of utility services that are in active use shall be scheduled and coordinated with Utility Companies and Representatives of Owner. Premium time required for installation of connections and relocations shall be included in bid. Services shall not be left disconnected at end of working day or weekend unless authorized by representatives of Utilities and Owner. Existing utility services damaged due to operation of Contractor shall be repaired to satisfaction of Owner and Utility Company at Contractor's expense.
- D. Failure to be acquainted with existing conditions under which work is to be performed will not be justification for additional compensation.

1.12 PERMITS AND INSPECTIONS

- A. Obtain required permits governing the contract work from Authorities Having Jurisdiction and assume cost of permits and inspections.
- B. Furnish to Owner certificates of observation or approval from Authorities Having Jurisdiction, if certificates of observation or approval are required by law or regulations, upon completion of work.
- C. Contractor shall assume the cost of labor and materials to conduct all required acceptance tests required by Local Code Enforcing Authority.

1.13 TRADE AND LOCAL PRACTICES

- A. Comply with local customs and labor trade agreements regarding trade or trades that shall be employed for installation of work.

1.14 PUBLIC UTILITIES

- A. Utility services shall be installed in strict accordance with standards of Utility Companies or Public Utility Agencies. Customer contribution, if required, shall be assumed by Contractor.

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1.15 TEMPORARY FACILITIES

- A. Use existing facilities. See Division 01.

1.16 CUTTING AND PATCHING

- A. See Division 01, GENERAL CONDITIONS.
- B. General: Structural members shall not be cut without first obtaining written permission from Engineer. Openings shall be core drilled or cut as applicable.
- C. Cutting:
1. Openings for conduit and cable in masonry materials shall be core drilled. Other openings shall be cut as necessary. See Section 260500, SLEEVES AND OPENINGS article for additional details.
 2. Make thorough investigation and field measurement by use of magnetic detection instruments or other approved means to detect concealed ferrous metal piping or conduit prior to cutting. Active piping, conduit or wire damaged due to this work shall be restored immediately. Restoration costs shall be at the expense of the Contractor.
 3. Cutting shall be limited to size necessary for working conditions. Consult with Contractor responsible for finish work and jointly develop method of cutting when surfaces are difficult or costly to replace.
- D. Patching and Finishing:
1. Patching:
 - a. Concrete or Concrete Block Surfaces: Patch opening with grout finished smooth with adjacent surface prior to applying final finish.
 - b. Gypsum Board or Plastered Surfaces: Patch opening with filler compound finished smooth with adjacent surface prior to applying final finish.
 - c. Special Finished Surfaces: Patch openings with appropriate material where surfaces are to have finishes such as glazed tile, paneling, stone or marble finish.
 - d. Painted Surfaces: Patch opening smooth with adjacent surfaces.
 2. Finishing:
 - a. Where surfaces have received their final finish prior to being cut or where the surface of an existing finish is cut, Contractor shall refinish surfaces to match the adjacent surfaces.
 - b. Contractor requiring the cutting shall be responsible for the quality of the finish work and make corrections to the refinished surfaces to maintain the quality of the finish to match the existing finish.
 - c. Maintain the watertight integrity of all penetrations of roofs or exterior walls and floors on or below grade.

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1.17 ORAL INSTRUCTIONS TO OWNER

- A. See Division 01.
- B. Assign responsible person who is thoroughly familiar with installed systems to give verbal instructions to Owner's assigned operating personnel whenever systems are turned over to Owner for operation.
- C. Direct specific instructions by factory-trained representatives shall be provided for following equipment and systems in addition to above general instructions.
 - 1. Wind/PV systems

1.18 MOUNTING AND LOCATIONS

- A. Location of Equipment and Devices:
 - 1. Locations of electrical equipment and devices shown are approximate. Determine exact location by checking drawings, field conditions and approved shop drawings.
 - 2. Relocate equipment or devices when directed by Engineer without cost, provided equipment has not been installed and new location is not greater than 10 ft. from location shown.
 - 3. Duplex power receptacles, telephone outlets, data processing outlets or other system outlets within room shall be located at same height, and of same vertical configuration.
 - 4. Wiring, signal and control devices shall be flush mounted in finished areas.
- B. Mounting Heights: Mounting heights shall be to center of device's outlet box unless otherwise indicated by existing conditions or Engineer details. Mounting height of devices and equipment shall comply with following schedules.
 - 1. Power Equipment:
 - a. Disconnect Switches, Contactors
and Time Switches.....4'-0" above floor
 - b. Panelboards or Relay Panelssee drawings

1.19 RECORD DRAWINGS

- A. See Division 01.
- B. Contractor shall provide Record Drawings to Owner within 90 days after the date of system acceptance.

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- C. Contractor shall keep day-to-day record of the installed items as follows:
1. Location of conduit concealed in walls, floors or above inaccessible ceilings. Record need not include exposed conduit or conduit above removable ceilings.
 2. Sizes and location of all feeders and their conduits changed from those shown on the original set of Contract Drawings issued for construction.
 3. Location of pull and junction boxes for power and control systems.
 4. All changes (additions or deletions) in branch circuit and feeder identifications (circuit numbers and/or load descriptions) different from those shown on the original set of Contract Drawings issued for construction. Panelboard directories shall be up-dated with the final load descriptions and circuit numbers that match those shown on the Record Drawings.
- D. CAD Drawings: One set of Engineering Bid Documents Drawings in electronic format will be issued to the Construction Manager or General Contractor at the time of bidding. One additional set of Engineering Drawings in electronic format will be issued to the Construction Manager or General Contractor at the completion of construction. Any copies of these documents requested by the Contractors or sub-Contractors shall be provided by the Construction Manager or General Contractor. Contractor shall transfer the projects record conditions recorded on job site prints, as outlined above, to the CAD drawings. No other electronic file updates will be provided by the Engineer.
- E. CAD Drawings: Contractor shall obtain from the Engineer a set of CAD drawings of the Contract Drawings in electronic format. Reference preceding GENERAL REQUIREMENTS article in this section for the contents of the CAD drawings in electronic format provided by WTA. Expense of CAD drawings shall be borne by Contractor. Contractor shall transfer the projects record conditions recorded on the blue line prints, as outlined above, to the CAD drawings.
- F. After correcting CAD drawings, Contractor shall submit the drawings to the Engineer for review prior to authorization for final payment to the Contractor. Contractor shall include the name, address and telephone number of his firm on each record drawing and provide a place for the certification signature. Record drawings shall be certified as to their correctness by signature of the Contractor and shall be stamped or otherwise identified as "RECORD DRAWINGS."

1.20 MAINTENANCE MANUALS

- A. See Division 01.
- B. Contractor shall provide maintenance Manuals to Owner within 90 days after the date of system acceptance.
- C. General: Contractor shall provide three (3) volumes of Maintenance Manuals at completion of project. Manuals shall be provided one week prior to Contractor's request for final observation.

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Manuals that include information on multiple systems are acceptable only when items not applicable to the system installed are crossed out.

1. Startup and Shutdown Procedures: Provide step-by-step write up of major equipment. Incorporate manufacturer's printed startup, troubleshooting and shutdown procedures.
2. Equipment List: Provide list of major equipment as installed. Wind/PV system panelboards, control devices, and termination kits shall include manufacturer, model number, ampacities, and nameplate data.
3. Service Instructions: Provide following information:
 - a. Recommended spare parts including catalog number and name, address and telephone number of local suppliers or factory representatives.
 - b. Lubrication and maintenance instructions for equipment.
 - c. Maintenance and operating instructions for special systems; i.e., and similar systems requiring routine attention.
 - d. Document Safety: Related work practices, procedures, and arc flash protective equipment for Owner employees and/or Contractors who work on or near exposed energized electrical equipment as required by the latest NFPA-70 E.
4. Include in manuals, parts catalogs for items of equipment furnished with components identified by number for replacement ordering.

D. Submission:

1. Manuals shall be in triplicate, and materials shall be neatly bound into volumes of standard 8-1/2 inch x 11 inch hard binders. Large drawings too bulky to be folded into 8-1/2 inch x 11 inch size shall be separately bound or folded into brown envelopes, cross-referenced and indexed with manuals.
2. Manuals shall include name of Engineer and all Contractors.
3. It is suggested that the Contractor submit one preliminary copy of manual to Engineer for precheck; and when approved, shall submit three (3) final copies through normal channels.

1.21 FINAL OBSERVATION

- A. See Division 01.
- B. Contractor shall review requirements of Contract Documents, observe work and inform parties involved of work to be corrected or completed before project can be deemed substantially complete.
- C. Notify Engineer in writing, when project is substantially complete listing those items of work remaining incomplete and anticipated date that remaining work will be completed. Final observation of project will then be scheduled by Engineer.
- D. Engineer reserves right to cancel and re-schedule observation in event considerable more work remains to be completed or corrected than indicated in written request for observation.

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- E. Representative of Contractor shall be present at Engineer's and Owner's final observation.
- F. Items not completed or found not complying with drawings or specifications by Engineer will be identified in observation report by Engineer.
- G. Copy of final observation report will be given to Contractor. Deficient items on observation report shall be corrected. Contractor shall initial and date items on report after corrections have been completed.
- H. Owner will make final check after items have been corrected. Contractor shall be present during final check and shall verify that corrections have been made.

1.22 ALTERATIONS AND DEMOLITION OF FACILITIES

A. General:

- 1. It shall be recognized that while work is confined to certain areas of building, work may have to be extended to include other areas in order that systems may be installed. Plan work in advance and obtain permission from Owner for work to be performed in multiple areas so that affected areas may be prepared by Owner. Interruption of access and power to areas where the Owner wishes to use the facility during construction shall be kept to minimum. Interruption of access to the existing buildings and site shall be kept to a minimum.
- 2. Note that most areas of the building work will be in-use during construction and work shall be phased to avoid interference with Owner's operations. Work may be required to be performed during other than normal working hours.
- 3. It is necessary that operation of electrical systems be interfered with as little as possible. Work which will interfere with operation of existing systems, or which requires downtime, shall be scheduled only after consultation with and receiving the permission of the Owner. Consultation shall be requested 10 days prior to anticipated interruption of systems serving any occupied areas.
- 4. Temporary connections shall be provided when any interruptions of electric services, special systems, security, and similar systems which serve other areas are necessary. These systems shall not be left out of operation for a weekend or overnight without permission from the Owner.
- 5. Make necessary provisions for protection of workers, other persons and property.
- 6. Inaccessible Raceways and Wiring: Assume responsibility for cutting and sealing of existing raceways and removal of wiring that is not permitted to be reused.
 - a. Investigate as required and identify raceways and wiring as to their source and point of termination. Prepare report for Owner indicating additional cost for performing following work:
 - 1) Active raceways and wiring in demolition path of or interfering with new construction or renovation work shall be cut, capped and removed, re-routed

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and reconnected when necessary to maintain service to active circuits. Coordinate and receive the Owner's approval before beginning the work.

- 2) Remove, or cap and abandon in place, as applicable, electrical raceways or wiring that are inactive or that will be inactive as result of this project.

7. Accessible Raceways and Circuits:

- a. No additional compensation will be allowed for conduit and circuits that are exposed or above lay-in ceilings or in accessible shafts, chases and floors that are accessible to the Contractor during the bidding period.
- b. Care shall be taken in removing access panels, ceiling tiles and raised floor panels. Contractor shall replace or repair any panels or tiles he damages. Repairs or replacement shall at least match the condition of panel or tile prior to their removal.

8. Check with maintenance personnel as to source of circuits and temporarily disconnect or shutoff circuits at nearest power source as appropriate.

- B. Concealed and Inaccessible Risers Not Shown On Drawings: Where existing walls or partitions are to be totally or partially removed and expose concealed electrical risers with wiring between floors that must remain in service and where such wiring must be relocated, Contractor shall locate source of concealed risers and/or wiring and shall furnish Owner cost estimate for relocation of same. Contractor shall receive written approval from Owner prior to commencing relocation work.
- C. Concealed and Inaccessible Services Not Shown On Drawings: Where existing walls or inaccessible ceilings are to be totally or partially removed and expose concealed electrical services feeding existing electrical equipment or devices that must remain in service and where such wiring must be relocated, Contractor shall locate source of electrical services and/or wiring and shall furnish Owner cost estimate for relocation of same. Contractor shall receive written approval from Owner prior to commencing relocation work.
- D. Exposed Risers or Services Not Shown on Drawings: No additional compensation will be allowed for electrical risers or services that must be relocated where risers or services are exposed or located above lay-in ceilings or in accessible shafts, chases, or raised floors that are accessible to Contractor during the bidding period.

1.23 TESTING

A. General:

1. Contractor shall be responsible for providing tests, and record of tests to Engineer and Authority Having Jurisdiction. Testing shall be performed by and under direct supervision of Contractor and shall be made only by qualified personnel fully experienced in this type of testing.
2. Contractor shall provide necessary test equipment. Checking of factory wiring and other preliminary work in preparing for electrical tests shall be responsibility of Contractor.

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3. Tests shall be scheduled with Owner and manufacturer's representative. Testing shall be during normal working hours unless otherwise indicated or specified.
4. Contractor shall correct faults, malfunctions or failures discovered during tests. Faulty equipment or devices shall be replaced with new equipment or devices provided by Contractor. Replaced equipment or devices shall be retested after replacement to verify their correct operation. When the equipment or device is part of a system, the system shall be retested to verify its correct operation.

B. Tests:

1. Tests are to insure that workmanship, methods, observations, and materials used in installation of equipment and systems conform to accepted engineering practices, electrical specifications and manufacturer's instructions.
 - a. Ground test
 - b. Insulation test
 - c. Visual test
 - d. Operational test
 - e. Acceptance test for FINAL OBSERVATION
2. Ground Test: Ground tests shall be performed at job site using appropriate test equipment. Maximum reading shall be 10 ohms.
3. Insulation Test:
 - a. Equipment Insulation Test: Insulation tests shall be performed at job site using Megger as appropriate to test equipment busses.
 - b. Conductor Insulation Test: Insulation tests shall be performed at job site using Megger as appropriate to test wire or cable.
4. Visual Test: Perform visual observation of equipment and connections at job site prior to operational test to prevent damage to equipment and harm to testing personnel.
5. Operational Startup Test:
 - a. Contractor shall make preliminary operational startup test at job site and provide certified test reports to Engineer prior to FINAL OBSERVATION.
 - b. Test reports of operational startup tests identified with complete data of readings, observations, and actions taken, shall be made into report for systems or piece of equipment tested. Provide minimum of three (3) test reports for each test to Engineer.
6. Acceptance Test: Acceptance test shall be run on selected devices and equipment during FINAL OBSERVATION. Acceptance will be determined by Engineer after reviewing preliminary operational startup test reports and equipment performance during operational test at job site. Final operational tests shall be performed on selected electrical equipment to show that equipment will correctly perform required functions.

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- C. Specific Tests: Field or job site tests shall be performed and test reports made for approval by Engineer for each of the following. An indexed binder with a copy of all of the tests shall be submitted to the Engineer for record prior to final observation by the Engineer and final payment by the Owner. Refer to specific articles in sections indicated for specific test requirements.
1. 600 Volt Feeders (Section 261200)
 2. Ground Fault Protection System (Section 264000)
 3. Wind/PV System Equipment (Section 263100)

1.24 GUARANTEE

- A. See Division 01, GENERAL CONDITIONS.
- B. General Guarantee:
1. Guarantee work against defects in labor and material for period of one year from date of Owner acceptance and Owner's takeover of equipment for use and maintenance.
 2. Starting date of guarantee for defective or incomplete system or equipment shall become effective only after correction of defects and completion of systems or equipment.
 3. Guarantee is not intended to cover damage resulting from Owner's misuse or to cover normal maintenance.
- C. Specific Warranty: See specific equipment specification for warranties extended beyond one year. Provide manufacturer's warranty of subject equipment to Owner prior to receiving final payment where warranties are specified. Warranties shall cover labor, material and travel expenses to repair and place equipment back in operation.

1.25 SUBMITTAL SUMMARY

- A. See the following Submittal Summary forms at the end of this section of specifications for detailed list of minimum submittal requirements.
- B. See specification section for specific details of submittal requirements. Contractor shall make a copy of the applicable forms and indicate an estimated date for each submittal in the column provided. Completed form shall be submitted to Engineer through proper channels within 4 weeks after date of contract. Dates submitted are subject to approval by the Engineer.

PART 2 - PRODUCTS

2.1 NOT APPLICABLE

PART 3 - EXECUTION

3.1 NOT APPLICABLE

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ELECTRICAL SUBMITTAL SUMMARY										
Spec. Section No.	Description of Submittal	Cat. Cuts	Plan, Elevat. & Details	Wiring Diag.	Bound Test Report	Schedule of Items	Requested Samples	Maintenance Manual	WTA Review Period (Weeks)	Contractor Estimated Submittal Date*
260100	Submittal Summary with Estimated Date*								2	
260100	Maintenance Manuals	X		X	X			X	4	
260100	Test				X				2	
260500	Firestop Systems	X							2	
260500	Flashing Boots	X							2	
261200	Conductors to 600 Volts and Tests	X			X				2	
261300	Conduit	X							2	
261950	Nameplates	X					X		2	
262400	Seismic Detail Report by Registered PE	X	X		X	X			4	
263100	Wind/PV System	X	X	X		X		X	2	
264000	Panelboards	X	X			X			2	
264000	Disconnect Switches	X	X						2	
264000	Fuses to 600 Volts	X							2	
264500	Grounding and Bonding and Tests	X	X		X			X	2	

END OF SECTION 260100

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DIVISION 26 – ELECTRICAL WORK

SECTION 260500 – BASIC ELECTRICAL MATERIALS AND METHODS

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SECTION 260500 - BASIC ELECTRICAL MATERIALS AND METHODS

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS, and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL MATERIAL REQUIREMENTS

- A. This section is intended to cover basic electrical materials and methods and their installation applicable to Contractor's work.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Equipment, devices or supports manufactured using metal or having metal surfaces, that require cutting in the field shall have cut surfaces or edges smoothed and refinished with primer and finish coats to match surface prior to being cut.
- D. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part numbers listed in this section are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be superseded, it shall be understood that newest equivalent series, model or part shall be furnished.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install basic electrical materials and methods as specified and indicated.

1.4 DESCRIPTION OF SYSTEMS

- A. Basic electrical materials and methods shall be provided as called for in this section of specifications.

1.5 SUBSTITUTIONS

- A. See Section 260100.

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1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100.
- B. Shop drawing submittals shall include but not be limited to the following:
 - 1. Firestop material
 - 2. Flashing boots

1.7 GROUNDING AND BONDING SYSTEMS

- A. Grounding and bonding of electrical system and equipment shall be provided in accordance with Section 264500.

PART 2 - PRODUCTS

2.1 SLEEVES AND OPENINGS

- A. General: Openings or holes in partitions, walls or floors shall be no larger than that necessary to allow passage of the electrical item and proper sealing of annular space. Provide sleeves and openings in partitions, walls and floors for electrical items. Sleeves and openings through fire or smoke partitions, walls or floors shall be sealed using a UL listed fire stop system. Reference FIRESTOP SYSTEMS article for manufacturers and details. Provide openings for cable, wire, raceway and similar items not otherwise provided for on Drawings. Holes through all exterior walls and through floors or roofs shall be sealed watertight. For openings in roofs reference ROOF OPENINGS article in this section.
- B. Manufacturer of Watertight Conduit Seals for Walls and Floors:
 - 1. Afterset Sleeves: Sleeves shall be as appropriate one of the following:
 - a. Concrete Wall or Floor (Core Drilled Holes):
 - 1) O-Z Gedney "CSM" Series or approved equal.
 - 2) Interlocking Link Type Seals: Provide interlocking link type seals of appropriate size and type for sealing annular space between conduit and wall or between pipe and Arlington appropriate "CPS" Series sleeve in exterior walls. Links shall be synthetic rubber; pressure plates, bolts, nuts and washers shall be stainless steel. Seals shall be suitable for watertight installation and shall withstand a hydrostatic pressure of 20 psi. Contractor shall have the option to use matching up Schedule 40 steel sleeve as provided by seal manufacturer.
 - a) Crouse-Hinds appropriate "Link-Seals" or approved equal.
 - b) Calpico Inc. appropriate "Pipe Linx" or approved equal.

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- b. Drywall Partition or Wall: Provide steel sleeve through wall or partition with washers and couplings and seal with appropriate fire stop material to maintain its smoke or fire rating.
 - 1) Afterset Sleeves: Sleeves shall be Unique Fire Stop Products (251)960-5018, or approved equal. Use UL listed systems SP, TP or SSS Series as required in 1 inch, 2 inch or 4 inch (I.D.) sizes.

2.2 FIRESTOP SYSTEMS

- A. General: Firestop systems shall be UL listed or Factory Mutual approved. Contractor shall select and install the proper firestop system with classified products and materials compatible with the type penetrating electrical elements, type of construction material and dimensions of the wall, partition, barrier, or floor and the environment and temperature range of both sides of the opening. Through penetration firestop systems shall maintain the original fire resistance rating of the wall, partition, barrier, or floor prior to the penetration. Expansion type firestop material shall be used where necessary to protect and close the opening upon failure of the penetrating electrical element due to fire.
- B. Firestop systems, meeting the above specification, shall be as manufactured by Johns Manville International Inc. - Firetemp Systems, CSD Sealing Systems, Specified Technologies Inc. (STI), 3M brand, Heavy Duty/Nelson, International Protective Coating Corporation, HILTI, Ciba-Geigy, Unique Fire Stop Products, or approved equal.

2.3 ROOF OPENINGS

- A. General: Provide and locate roof openings for electrical raceways for providing electrical service to rooftop photovoltaic and wind turbines.
- B. Flashing Boots: Flashing base shall be aluminum, PVC or EPDM as appropriate. Flashing caps for base or flashing boots shall consist of EPDM compression molded rubber and stainless steel clamps.
- C. Manufacturer of Flashing Boots: Openings for conduit passing through roof shall be made watertight by means of flashing boots manufactured by Roof Products and Systems Corp., The Pate Co., Portals Plus Inc., or approved equal.

PART 3 - EXECUTION

3.1 SLEEVES AND OPENINGS INSTALLATION

- A. General:
 - 1. Building Structural Members: Sleeves are not permitted through concrete structural members unless indicated on the Drawings or approved by the Architect/Engineer.

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2. Openings or holes shall not be larger than that required to install the sleeve or electrical item and firestop system or watertight seal.

B. Sleeves:

1. Sleeve shall be provided in openings required for passing conduit 2 inch and larger, through smoke or fire partitions, walls or floors. Sleeves shall be provided for all conduits penetrating smoke or fire partitions, where conduit crosses a building expansion joint located within 6 ft. of the penetration. Sleeves shall allow the electrical item to expand and when necessary, be easily replaced or repaired without increasing the size of the opening. Since materials and systems vary by manufacturer details shown on the drawings are for illustrative purposes only. Contractor shall provide firestop system meeting preceding FIRESTOP SYSTEMS article.
2. Sleeves shall be Schedule 40 black steel extended 6 inches beyond face of partition or floor surface, with threads and caps at each end.
3. Sleeves shall be solidly set in opening. Sleeves shall be appropriate size for passage of electrical item. Annular space shall be sealed in accordance with latest NEC using UL listed material.
4. Afterset Sleeves: Contractor shall provide openings for sleeves through existing walls or floors. Opening shall not be larger than that required for installation of the sleeve. Surfaces in area of penetration shall be cleaned of loose particles and dust. No moisture or oil on surfaces shall be present. Wall sleeves shall extend 6 inch beyond both sides of opening and floor sleeves shall extend a minimum of 2 inch above the floor to provide a water stop.
5. Burrs and sharp edges of sleeves shall be filed smooth.
6. Sleeves provided for future electrical items and those sleeves installed but not used shall be completely sealed with appropriate firestop material.

C. Sleeves in Exterior Walls:

1. Electrical items penetrating exterior walls shall pass through Schedule 40 galvanized, PVC coated steel sleeves or other sleeves with appropriate coating to prevent rusting.
2. Reference INSTALLATION OF CONDUIT AND TUBING article in Section 261300 for requirements of sleeves for conduit used in outdoor work.
3. All items run through sleeves in exterior walls shall be sealed watertight.

D. Sleeves in Indoor Walls and Partitions:

1. Raceways and Cable Penetrations:
 - a. Masonry or Concrete: Electrical items penetrating masonry or concrete walls shall pass through Schedule 40 black steel pipe sleeves.
 - b. Drywall or Gypsum Board: Electrical items passing through new drywall or gypsum board partitions shall pass through Schedule 40 black steel pipe or 20 gauge galvanized sheet steel sleeves.

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E. Floors:

1. Conduit over one inch shall be installed in sleeves. See INSTALLATION OF CONDUIT AND TUBING article in Section 261300 for additional requirements. All cables run through floors shall be run through sleeved openings.
2. Cable or conduit run through floors in unfinished spaces where water could drain to floor below shall be provided with Schedule 40 pipe sleeves extending a minimum of 1 inch above floor to serve as a water stop. Sleeves in finished areas shall terminate flush with floor and shall be Schedule 40 pipe or 20 gauge galvanized steel sheet metal at Contractor's option. Fill space between the cable or conduit and the sleeve with approved firestop materials.

F. Roofs: Reference ROOF OPENINGS article in this section for details.

3.2 FIRESTOP INSTALLATION

- A. Firestop System Installation: Annular spaces between cable, wire, conduit, and sleeve or hole shall be properly sealed with an approved firestop material. Firestop material may be putty, foam, caulking mortar, wrap or tape as appropriate. Firestop material shall be installed in accordance with manufacturer's instructions. An approved firestop method shall be provided by the Contractor to maintain the original fire rating of the wall, partition, barrier or floor. The firestop system material shall be manufactured by one of those listed in PART 2 of this section of specifications.
- B. Verify and coordinate work with other items by other contractors in the same area that penetrate the fire rated wall, partition, barrier or floor have been installed prior to installation of the firestop system.
- C. Where the firestop system is located at a penetration that would be concealed. The Contractor shall have the Authority Having Jurisdiction; verify its installation prior to its concealment (i.e. penetrations through fire rated walls above drywall ceilings).
- D. Contractor shall correct all unacceptable firestop systems found at no additional cost.

3.3 ROOF OPENINGS INSTALLATION

A. Roof Openings:

1. Contractor shall provide flashing boots of appropriate size and type to match the roof construction and item run through the flashing boot.
2. Existing Roofs:
 - a. Contractor shall provide as part of his work a roofing subcontractor specializing in this type of work with minimum of 3 years experience to provide sealing of necessary holes in existing roofs in order to maintain their watertight integrity.

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- b. Roofing Subcontractor shall provide all material necessary such as roofing felt, aggregate, cements and counterflashing necessary to provide complete watertight roof penetration guaranteed for minimum of 5 years.
- B. Flashing boots or base with cap shall be prefabricated type in accordance with details and dimension provided by the Contractor furnishing the conduit or cable.
 - 1. Manufacturer of Flashing Boots: Openings for conduit passing through roof shall be made watertight by means of flashing boots. Flashing boots, meeting the above specification, shall be manufactured by Roof Products and Systems Corp., The Pate Co., Portals Plus Inc., or approved equal.

3.4 CONCRETE WORK

- A. Housekeeping Pads for Equipment: Unless otherwise noted, housekeeping pads for electrical equipment shall be provided. In general, housekeeping pads shall be 4 inch high unless otherwise indicated.
 - 1. Location, size and configuration of housekeeping pads as shown are approximate and will vary with final equipment selection. Contractor shall be responsible for coordinating pad sizes and location with size of equipment installed, equipment anchoring holes and seismic anchors. Concrete shall extend a minimum edge distance of 4 inch or ten (10) anchor bolt diameters whichever is larger clear of all sides of the equipment.
 - 2. Contractor requiring pad shall provide appropriate anchors and anchor bolts. Where seismic anchoring is required, anchoring shall be in accordance with subparagraph 5. below.
 - 3. Concrete shall be small aggregate, 4000 psi compressing strength in 28 days in accordance with ACI 318. Building's floor surface shall be roughened or have bonding agent applied prior to pouring pad.
 - 4. New Pads for Existing Structures: Pads shall be anchored to structural floor slab by the use of 3/4 inch anchor bolts or studs. Anchors bolts or studs shall project a minimum of 2 inch when fully engaged with anchor. Pad anchors shall be located one quarter of the pad width or length from the edge of the pad and on maximum of 24 inch centers. Where seismic anchoring is required for equipment, pad anchors shall be coordinated with location of seismic anchors.
 - 5. Seismic Anchors for Equipment on Pads: Installation of equipment on pads shall be able to resist seismic forces, see Section 262400 - VIBRATION AND SEISMIC CONTROL for embedment requirements of seismic anchor bolts. Seismic anchor bolts shall extend to proper depth through the concrete housekeeping pad into buildings structural floor slab where applicable.
- B. Foundations for Heavy Equipment:
 - 1. Where indicated, equipment such as large inverters shall be installed on structural concrete foundations as determined on structural plans. Contractor shall furnish dimensions of equipment to the General Contractor.
 - 2. Contractor shall furnish and install anchors, anchor bolts and vibration isolators.

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3.5 LINTELS

- A. Provide lintels as required for support of building construction above conduits, boxes, panels, and conduits where openings are cut in existing or already completed wall.
- B. Lintels shall be structural steel angles, channels or tees of proper size and sections for supported load.

3.6 PAINTING

- A. Work Included:
 - 1. Conduit, boxes and steel supports (except materials fabricated of galvanized steel, aluminum or PVC) exposed to weather on roof, or exterior of building shall be painted.
 - 2. Supporting steel, boxes and hangers for conduit and equipment (except made of galvanized steel) shall be shop coated with rustproof primer or shall be field painted except where installed indoors above ceilings or where concealed in shafts. Hangers and boxes in mechanical spaces shall receive a field coat over primer.
- B. Work Not Included: Conduit in mechanical rooms, machine rooms, pipe chases and duct shafts will not be painted.
- C. Manufacturer's Finished Products:
 - 1. Manufacturer's finished products for electrical equipment shall have factory standard finish except where otherwise specified.
 - 2. Touch up minor damages or scratches due to shipment, installation or exposure to weather on equipment with baked or sprayed enamel or equivalent finish. Prime-coated equipment shall be cleaned but will not require touch-up. Large areas of damaged finish shall be painted to match factory finish.
- D. Painting Specifications:
 - 1. General:
 - a. Painting work shall be performed by required trades and in a neat and workman-like manner. Painting materials shall be of best quality and suitable for service intended.
 - b. Surfaces to be painted shall be free of rust, scale, peeling, blistering, grease, oil, or deteriorating film prior to application of primer.
 - c. Finish paints shall present a glossy finish. Quantity of finish coats shall be two (2) unless otherwise indicated.
 - d. Colors: Color of finish paints will be selected from manufacturer's standard colors. Red primers are specified, however, gray or white primers can be used on items to be finished with white, yellow or other lighter finish colors provided they meet the red primer's specifications.

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- e. Curing shall be in accordance with manufacturer's instructions.

END OF SECTION 260500

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SECTION 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS)

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL MATERIAL REQUIREMENTS

- A. This section is intended to cover conductors, cables and connectors to 600 volts and their installation applicable to Contractor's work.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Equipment, devices or supports manufactured using metal or having metal surfaces, that require cutting in the field shall have cut surfaces or edges smoothed and refinished with primer and finish coats to match surface prior to being cut.
- D. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part numbers listed in this section are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be superseded, it shall be understood that newest equivalent series, model or part shall be furnished.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install conductors, cables and connectors as specified and indicated.

1.4 DESCRIPTION OF SYSTEMS

- A. Conductors, cables and connectors shall be provided as called for in this section of specifications.

1.5 SUBSTITUTIONS

- A. See Section 260100.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100.

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B. Shop drawing submittals shall include but not be limited to the following:

1. Conductors (to 600 volts) tests
2. Connection devices (to 600 volts)

1.7 GROUNDING AND BONDING SYSTEMS

- A. General: Grounding and bonding of electrical system and equipment shall be provided in accordance with the NEC.
- B. Grounding and Bonding: Reference Section 264500 - GROUNDING AND BONDING for grounding of non-current carrying metallic parts of electrical equipment using the equipment grounding conductor.

PART 2 - PRODUCTS

2.1 CONDUCTORS (TO 600 VOLTS)

A. General:

1. This article applies to low voltage wire and cable for application to systems of 600 volts or less. This also applies to factory assembled wire and conduit systems such as metal-clad cable (MC). Conductors shall be UL listed.
2. Low-voltage conductors used on systems to 600 volts shall be installed in a raceway system unless otherwise indicated. Conductors located in air plenums but not in steel raceways shall have "plenum rated" type insulation.
3. Electrical Connections: Size (AWG) of conductors used shall be based on their temperature rating while not exceeding the temperature rating of both line and load side equipment listed or identified for use with such conductors.

B. Materials and Applications:

1. Conductor Material and Stranding: Conductors shall be insulated copper. Feeder and branch circuit conductors #8 AWG and larger shall be stranded unless otherwise indicated.
2. Building Wire and Cable: Building wire and cable shall have 600 volt insulation with continuous operating temperature rating indicated. Building wire and cable shall be used for following applications:
 - a. Feeders and Branch Circuits (#12 AWG and Larger): For feeders and branch circuits run in raceways unless otherwise noted, use required quantity of conductors in sizes #12 AWG and larger. Insulation of conductors shall be type THWN/THHN, dual rated for 167 deg. F. wet, 194 deg. F. dry, with nylon jacket.
 - b. Feeders and Branch Circuits (#4 AWG and Larger): For feeders and branch circuits run in raceways, use required quantity of stranded conductors in sizes #4

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- AWG and larger. Insulation of conductors shall be Type XHHW, dual rated for 167 deg. F. wet, 194 deg. F. dry.
- c. Control Circuits for Lighting and Power (#14 AWG and Larger): For lighting and power control circuits run in raceways to control devices, use stranded, single conductor sizes #14 AWG and larger. Conductor insulation shall be Type THWN/THHN dual rated for 167 deg. F. wet, 194 deg. F. dry, with Nylon jacket.
 - d. Metal-Clad Cable (Type MC): Metal-clad cable shall be factory assembled multi-conductor cable provided with an equipment grounding conductor. Conductors shall be insulated, be grouped together and be enclosed in a single metallic sheath. Cable shall be manufactured in accordance with UL 1569.
- 1) Concealed Dry Location Branch, Circuits #12 Through #2 AWG: For concealed indoor dry location branch, circuits use interlocked galvanized steel sheathed, multi-conductor, metal-clad cable with copper conductors in sizes #12 through #2 AWG. Insulation of conductors shall be THHN rated for 194 deg. F.
- 3. Photovoltaic System (DC) Conductors (#6 AWG and Larger): For the photovoltaic systems wiring from photovoltaic panels to photovoltaic inverters, use flexible Class K (#30 AWG) stranded bare soft copper cable with EPR insulation rated for 194 deg. F.
 - 4. Low Voltage Control Switching System: For low voltage control wiring, use multi-conductor or plenum rated multi-pairs in minimum #16 AWG stranded copper with shield when run above ceiling in conduit.
 - 5. Auxiliary Systems: Low voltage wiring for signal, control, or communication systems shall be provided in accordance with NEC.
 - 6. Building Wire Color Coding:
 - a. General:
 - 1) All conductors shall be insulated and color coded unless otherwise indicated.
 - 2) Conductors shall be continuous and of the same color identification from point of origin to point of termination throughout each system. However, conductor jacket or insulation for #4 AWG and larger used on AC power systems need not be color coded their entire length but shall be identified at all termination points including junction and pull boxes by means of 1/2 inch color taping or painted band.
 - 3) Wire or cable with white, gray, green or green with yellow tracer insulation shall not be used for ungrounded AC power branch circuits or feeder conductors.
 - 4) Existing Areas: Contractor shall verify color coding of each existing electrical system and match in order to prevent changing of phase identifications and changes of existing motor phase rotation where they are being refed.
 - 5) Neutrals of Different Systems in Same Enclosure: Neutrals of different systems shall be identified differently. One system neutral may be "white"

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or “gray” and the other must be “white with a color stripe” (not green) its entire length.

- b. Branch Circuits: Insulation of branch circuit conductors for each AC power electrical system shall be, unless otherwise indicated, color coded as follows:

120/208 volt, 3 phase, 4 wire

Phase A = black
Phase B = red
Phase C = blue
Neutral = white

208 volt, 3 phase, 3 wire

Phase A = black
Phase B = red
Phase C = blue

277/480 volt, 3 phase, 4 wire

Phase A = brown
Phase B = yellow
Phase C = orange
Neutral = gray

480 volt, 3 phase, 3 wire

Phase A = brown
Phase B = yellow
Phase C = orange

- c. Feeders Circuits: Insulation of AC feeder circuit conductors shall be color coded the same as the branch circuits.
- d. Equipment Grounding Conductor: Insulation of the equipment grounding conductor run with the AC circuit conductors shall be green or be bare.

7. Building Wire Conductor Sizes:

- a. Branch Circuits: Minimum size wire for AC branch circuits shall be #12 AWG, however, lighting and power branch circuits shall be sized for maximum 3.0 percent voltage drop. Branch circuit runs in excess of 75 ft. shall be a minimum #10 AWG. Branch circuit runs in excess of 125 ft. shall be minimum #8 AWG. All 120 volt branch circuit wiring in conduit to a 20 amp single pole circuit breaker shall be sized in accordance with following table.

PERCENT VOLTAGE DROP TABLE FOR THWN 75 DEG. C.									
WIRE NOT EXCEED 'G	50 FT.	75 FT.	100 FT.	125 FT.	150 FT.	175 FT.	200 FT.	250 FT.	300 FT.
#12 AWG	2.1%	3.2%							
#10 AWG	1.4%	2.1%	2.8%	3.5%					
#8 AWG	0.9%	1.3%	1.8%	2.2%	2.7%	3.2%			
#6 AWG	0.6%	0.9%	1.2%	1.5%	1.8%	2.0%	2.4%	2.9%	3.5%
MAXIMUM 14 AMPS, 120 VOLTS AT 0.80 P.F.									

- b. Feeder Circuits: Electrical distribution feeders for electrical systems shall be sized as shown.
- c. Lighting and Power Control Circuits: Minimum size conductor for lighting and power control wiring shall be #14 AWG. Smaller sizes may be used if fuse overcurrent protection does not exceed the current carrying capacity of the wire.

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8. Auxiliary Systems: Wiring for signal, control or communication systems shall be color coded as follows:
 - a. Auxiliary System Circuits: Auxiliary system circuits shall be color coded and numbered in accordance with system manufacturer's recommendations or in manner approved by Engineer.
9. Low Voltage Control Switching System Cables Above Suspended Ceilings: Low voltage control switching system cables to be installed above suspended ceilings shall be provided with J-hooks for a small bundle of cables. J-hooks shall be fastened to an independently hung drop wire. J-hook supports shall provide 0.45 lb/ft. loading and meet 1997 TIA 569-A.
10. Auxiliary System Cable Supports Above Suspended Ceilings: Auxiliary system low voltage cables to be installed above suspended ceilings shall be provided with J-hooks for a small bundle of cables. J-hooks shall be fastened to an independently hung drop wire.

C. Manufacturers:

1. Building Wire: Building wire manufacturers shall be American Insulated Wire, Aetna Insulated Wire, Southwire Co., Encore Wire Corp., or approved equal.
2. Metal-Clad (MC) Cable, Box Fittings and Support Clips:
 - a. MC Cable:
 - 1) Dry location interlocked steel or aluminum sheathed metal-clad cable with copper insulated 194 deg. F., THHN phase, neutral and grounding conductors and associated box fittings manufacturer shall be ALFLEX (Armorlite), Coleman Cable Co., AFC/A Monogram Co., or approved equal.
 - 2) Squared aluminum sheathed metal-clad cable with copper insulated 194 deg. F., THHN phase, neutral and grounding conductors and associated box fittings manufacturer shall be Coleman Cable Co., or approved equal.
 - b. MC Cable Fittings:
 - 1) Fittings for interlocked aluminum sheathed metal-clad cable shall be Killark (Clencher), O-Z Gedney Co. (Fast-Fit), Thomas & Betts (Spin-On), O-Z Gedney Co. (Speed-Lock), or approved equal.
 - 2) Fittings for interlocked aluminum sheathed metal-clad cable with PVC jacket shall be Killark, O-Z Gedney Co., PLM, Thomas & Betts, or approved equal.
3. Supports for Cables (Not-in-Raceway or Cable Tray) Above Accessible Ceilings: Wire or cables supported above accessible ceilings not in conduit or cable trays shall be supported above the ceiling on independently hung support wires on ring, hook or loop type hangers manufactured by ERICO Products Inc., Arlington Industries Inc., CPI (Chatsworth Prod. Inc.), B-Line, or approved equal. Grommet material for protection of cables shall be Arlington Industries Inc. (The Centipede), or approved equal.

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4. Photovoltaic System (DC) Wiring: Manufacturers of flexible Class K (welding cable) shall be American Insulated Wire, Rome Cable Corp., Triangle PWC Inc., Prysmian Cables and Systems, Southwire Co., or approved equal.

2.2 WIRE CONNECTIONS AND DEVICES (TO 600 VOLTS)

A. General:

1. This article applies to all wire and cable connections and devices used on systems of 600 volts or less.
2. Connection devices shall be UL listed to match the required wire or cable size combination. Compression and mechanical lugs and connectors shall be dual-rated AL/CU to meet UL 486B test for 194 deg. F.
3. Compression lugs and connectors shall be installed using hydraulic tools compatible with lugs or connectors to be installed. Lugs shall have NEMA standard bolt holes to match bolt diameter and quantity for equipment terminations.
4. Connectors and devices shall be compatible with voltage, grounding requirements, size conductor, type conductor, type shield, and type terminal to which they are to be attached.
5. Complete Part Numbers: Manufacturer's series number, type number and kit number, are to establish type and standard of quality. Contractor shall add or delete as necessary proper prefix, suffix, options and accessories to provide required components to make proper connection.
6. Feeders shall always be continuous or free of both tap splices and straight splices, from the protection device to the equipment unless otherwise indicated.

B. Materials and Applications:

1. Feeder or Large Branch Circuit Straight Splices: Straight splices for feeder in sizes #6 AWG through 1500 kcmil shall be made in junction boxes or other appropriate enclosures. Splices shall have compression connectors and cold shrink insulators.
2. Indoor Branch Circuit Taps and Straight Splices (#8 AWG or Smaller): Branch circuit copper wire taps and straight splices in junction boxes shall be made using appropriate connectors. Connectors shall be reusable, pressure type spring steel connectors with color-coded insulator good for #8 AWG or smaller solid and stranded conductors. Connectors shall be rated for maximum 221 deg. F.
3. Outdoor 120 or 277 Volt Branch Circuits: Connectors rated 221 deg. F. for outdoor branch circuits shall be pressure, wire, spring steel type. Connectors shall be UL listed waterproof type with retention fingers and waterproof sealant.

C. Manufacturer:

1. Feeder or Large Branch Circuit Straight Splices:
 - a. Straight Splices: Straight type splices in junction boxes used for splicing conductors in sizes #2 AWG through #2/0 AWG; #2/0 AWG to 250 kcmil; 250

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kcil through 700 kcil and 750 kcil through 1500 kcil provide 3M series 8400 kits consisting of compression type connectors and cold shrink insulators.

2. Indoor Branch Circuit Splices (#8 AWG or Smaller): Connectors shall be 3M Scotchlok-2; Ideal Industries WIRE-NUT or WINGNUT; Buchanan Construction Products Inc., Elastimold Division of Amerace Corp., WAGO Corp. WC or WD (no-twist) series, or approved equal. Connectors for control wiring may be 3M Scotchlok self-stripping tap connectors 560 Series, or approved equal.
3. Outdoor Branch Circuit Splices:
 - a. Outdoor 120 or 277 Volt Branch Circuit Connectors 221 deg. F.: Connectors for 120 or 277 volt outdoor lighting branch circuits in outdoor boxes, fixtures or poles shall be King Technology "One-step," Ideal Industries "DB-Plus," Buchanan "B-CAP Twist and Seal" rated for 600 volts, or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION AND TESTS OF CONDUCTORS (TO 600 VOLTS)

A. General:

1. Wiring shall be installed in approved raceways unless otherwise indicated.
2. Contractor shall follow conductor manufacturer's installation instructions and shall not exceed conductor's recommended maximum pulling tension (tensile strength) or minimum bending radius.
3. Parallel Conductors in Metallic Conduit: Where 3 phase power is required to be run using parallel conductors per phase and they are run in multiple metallic conduits, each conduit shall contain all 3 phases to prevent heating surrounding metal by electromagnetic induction.
4. Large Cable Bending: Where cables in sizes No. 1/0 to 750 kcil are required to be bent to make terminations, special cable bending tools with aluminum rollers shall be used to provide a smooth, scuff-free bend.
5. Pulling Lubricants: Cable pulling lubricants shall be UL listed and be compatible with type jacket on cable being installed. Wire pulling compound must not set up to prevent future removal of conductors from conduit.
6. When pulling cables with connectors already attached, Contractor shall isolate the mechanical pulling forces from the connector.
7. Properly prepare cables and/or wires by cutting and stripping of jacket and insulation prior to making terminations. Care shall be taken to avoid ringing of conductor with stripping tool.
8. When installing cable or wire at low temperatures the insulation and jacket materials lose flexibility. To keep cable flexible it shall be placed in heated area for at least 48 hours prior to installation.
9. Auxiliary Systems: Auxiliary system wiring shall be installed in strict accordance with manufacturers wiring diagrams. Reference Section 263100 for additional information on photovoltaic and wind turbine wiring requirements.

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- B. Indoor Wiring for Feeders and Branch Circuits: Indoor power wiring for feeders and branch circuits shall be installed in raceways.
1. Exposed Cable Connections to Electrical Equipment:
 - a. For short cable runs exposed and terminating in cabinets or equipment, cable support cabinet bushings shall be provided and be sized as recommended by bushing manufacturer.
 - b. Exposed cable runs in interior of switchboards and switchgear shall be adequately supported with rigidly mounted horizontal supports and cable ties, on maximum 2 ft. centers.
 2. Spare Wires: Spare wires shall be provided where indicated. Spare wires shall be run to outlet box, pull box or junction box and shall be identified with tag indicating equipment or panel in which it originated. Spare wires shall be of sufficient length for termination.
 3. Grounding Conductor: Branch circuits shall have insulated copper grounding conductors.
 4. Photovoltaic and Wing Turbine DC Conductors: Branch circuit and feeders with these conductors shall be installed a separate raceway from other wiring.
 5. Photovoltaic System DC Feeders: Cable shall be installed in accordance with NEC in conduit or cable tray as indicated. Run equal number of positive (+) and negative (-) cables in each conduit with an equipment grounding conductor.
- C. Indoor Auxiliary System Wiring For Signal Control and Communications Circuits:
1. Signal, control and communication (not voice and data) wire and cable shall be run in conduit unless otherwise noted.
 2. Identification: Auxiliary system circuit wiring shall be identified by color code and at both ends with self-adhesive numbers and wire tags as designated on equipment manufacturer's installation drawings.
 3. Metal-clad cable (MC) for auxiliary system wiring may be used in lieu of wire and conduit concealed in stud partitions and in accessible ceilings where not subject to physical damage. Where MC cable is exposed to moisture provide watertight boxes and cable bushings.
- D. Outdoor Wiring for Feeders and Branch Circuits:
1. Outdoor branch circuits and feeders on building or structure shall be run in rigid steel conduit unless otherwise indicated.
 2. Conduit entries into buildings shall be sealed watertight and wiring inside conduits shall be sealed watertight.

3.2 INSTALLATION OF WIRE CONNECTIONS AND DEVICES (TO 600 VOLTS)

- A. Material Table: Conducting material of wire, termination devices and electrical equipment busses shall match as follows:

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<u>Equipment Bus</u>	<u>Lugs Labeled</u>	<u>Terminating Conductor</u>
Copper	AL9CU	Copper
Aluminum	AL9CU	Copper
<u>Splice Wire (A)</u>	<u>Connector</u>	<u>Splice Wire (B)</u>
Copper	AL9CU	Copper
<u>Motor Term. Wire</u>	<u>Connector</u>	<u>Motor Br. Crkt. Wire</u>
Copper	AL9CU	Copper

- B. Indoor Wiring Connectors for Feeders and Branch Circuits: Field installed connectors shall be made in outlet boxes, junction boxes, equipment, or other appropriate enclosure.

1. Indoor Feeder Splices:

- a. Appropriate size and type of compression fittings and insulation shall be applied on feeder conductors to provide secure and positive electrical connection.
- b. In-line feeder splices shall be installed in strict accordance with manufacturers instructions.

2. Indoor Branch Circuit Splices: Appropriate size and type of connectors shall be manually twisted or pushed onto branch circuit conductors to provide secure and positive electrical connection. Connector's integral insulator shall completely cover bare portion of stripped conductor.

3. Fixture Wire Nuts: Lighting fixture branch circuit conductor connections in junction and outlet boxes shall be made with UL listed pressure type spring connectors rated at 600 volts maximum or 1,000 volts maximum when enclosed in fixture or sign.

- C. Outdoor Wiring Connectors for Feeders and Branch Circuits: Field installed connectors shall be made in outlet boxes, junction boxes, equipment, or other appropriate enclosure.

1. Outdoor Feeder Splices:

- a. Appropriate size and type of compression fittings, insulation or kits shall be applied on feeder conductors to provide secure and positive electrical connection.
- b. In-line feeder taps and splices shall be installed in strict accordance with manufacturer's instructions.

2. Outdoor Branch Circuit Splices: Appropriate size and type of connectors shall be manually twisted or pushed onto branch circuit conductors to provide secure and positive electrical connection. Connector's integral insulator shall completely cover bare portion of stripped conductor. Branch circuit wiring connections shall be made in weatherproof junction and outlet boxes.

END OF SECTION 261200

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SECTION 261300 - RACEWAYS AND BOXES

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL MATERIAL REQUIREMENTS

- A. This section is intended to cover raceways and boxes, and their installation applicable to Contractor's work.
- B. Equipment, devices or supports manufactured using metal or having metal surfaces, that require cutting in the field shall have cut surfaces or edges smoothed and refinished with primer and finish coats to match surface prior to being cut.
- C. Outdoor and Wet Locations: Where the term outdoor is used in this section of specifications it shall also be defined as indoor wet location. Devices or equipment specified as outdoor shall meet code requirements for wet locations and shall be applicable for use in indoor wet locations.
- D. Coordination: Conduit, pull and junction boxes giving right-of-way priority to systems such as plumbing, fire protection, piping, and drain lines required to be installed at a specified slope where space is available.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install raceway and boxes as specified and indicated.

1.4 DESCRIPTION OF SYSTEMS

- A. Raceways and boxes shall be provided as called for in this section of specifications.

1.5 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. Shop drawing submittals shall include but not be limited to the following:
 - 1. PVC coated raceway
 - 2. Rigid PVC raceway

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PART 2 - PRODUCTS

2.1 CONDUIT AND TUBING

A. General:

1. Conduit and fittings shall be UL listed.
2. Minimum size of conduit shall be 1/2 inch.
3. Reference PART 3 - EXECUTION for product application information.
4. Conduit sizes shall be as indicated with conduit fill not to exceed 40 percent.
5. Seismic Requirements: Conduits required to have seismic supports shall be provided with supports in accordance with Section 262400 - VIBRATION AND SEISMIC CONTROL.
6. Routing of Indoor Conduit: Conduit shall be concealed in finished areas in walls and above ceilings. Conduit shall be installed in straight vertical and horizontal runs parallel with and perpendicular to building structural members.

B. Materials and Applications:

1. Rigid Metal Conduit (RMC) or Intermediate Metal Conduit (IMC): RMC or IMC conduit shall be hot-dipped galvanized steel or electro galvanized steel. Raceways shall have sharp, clean threads and meet Federal Spec. WW-C-581. Running threads for this conduit are not permitted.
2. EMT Steel Conduit: EMT steel conduit shall be made from mild steel and be electrically welded and galvanized. EMT or Electrical Metallic Tubing shall meet ANSI-C80 and Federal Spec. WW-C-563.
3. Flexible Metal Conduit: Flexible metal conduit shall be interlocked armor, galvanized steel and only be used in dry locations. Flexible metal conduit shall meet Federal Spec. WC-566.
4. Liquidtight Flexible Metal Conduit: Liquidtight flexible steel conduit with moisture and oilproof gray PVC jacket shall be used for vibration isolation between mechanical equipment and the conduit system. Conduit shall be rated for ambients between -40 deg. F. to +140 deg. F. Liquidtight flexible metal conduit shall meet UL 360.
5. Liquidtight Flexible Non-Metallic Conduit: Liquidtight flexible non-metallic conduit shall be flame-resistant and have UL listed fittings. Maximum size is 2 inch.
6. Electrical Non-Metallic Tubing (ENT): ENT shall be flame-retardant, resistant to moisture and chemical atmosphere, and be UL listed. ENT to max. 1 inch size shall meet NEC and be suitable for use with 194 deg. F. conductors operating to 600 volts.
7. Unions, Couplings and Fittings:
 - a. RMC or IMC Steel Conduit Fittings:
 - 1) RMC or IMC steel connecting devices shall be galvanized threaded type and meet Federal Spec. W-F-408. Threads shall be full and clean cut to match conduit.
 - 2) Grounding type insulated bushings and locknuts shall be used on RMC or IMC steel conduits that enter metallic enclosure of switchgear,

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- switchboards, motor control centers, panelboards, pull boxes and junction boxes. Grounding bushings with insulated throat for RMC or IMC steel conduit shall be O-Z/Gedney Type IBC (Lay-In-Lug), Midwest Electric (Lazy-Lug), Thomas & Betts (Blackjack), or approved equal.
- 3) Expansion fittings shall be provided on exposed raceway at building expansion joints and where required to compensate for thermal expansion and contraction. Deflection/expansion fittings shall be provided in embedded raceway in building expansion joints.
 - a) Raceway: RMC or IMC with internal bonding; Expansion Fitting Manufacturer/Type: O-Z/AX, Spring City/AF, Cooper Crouse-Hinds/XJG, or approved equal.
 - b) Raceway: RMC or IMC with external bonding for outdoors; Expansion Fitting Manufacturer/Type: O-Z/EX, Spring City/EF, Cooper Crouse-Hinds/XJG/GJ, or approved equal.
 - c) Raceway: RMC or IMC watertight (NEMA 4) with neoprene sleeve and stainless steel bands for concrete pours; Deflection/Expansion Fitting Manufacturer/Type: O-Z/DX, Spring City/DF, Cooper Crouse-Hinds/XD, or approved equal.
 - 4) Insulation bushings shall be provided on IMC or RMC conduit stubs above ceilings or to cable tray. Insulation bushings shall be O-Z/Gedney Type A, Arlington RGD Series, or approved equal.
 - 5) Conduit bodies shall only be used where indicated or specified. Conduit bodies shall be made from cast malleable iron, Feralloy or copper free aluminum and have threaded openings and blank covers with neoprene gaskets held in place with two (2) stainless steel screws. Bodies shall be LB, C or other type as required.
 - 6) Integral RMC or IMC steel fittings for 2 inch through 4 inch conduit shall be KWI-K-Couple manufactured by Allied Tube & Conduit Corp., or approved equal; however, this conduit may not be used in hazardous areas.
 - 7) Bolt-on hubs, sealing locknuts or Scru-Tite hubs shall be provided on box connections in wet locations.
 - 8) Conduit Sealing Bushings: Conduit sealing bushings shall be used to provide a watertight seal of wiring inside threaded IMC or RMC steel conduit at switchgear, switchboard, panelboard, or box entries.
- b. PVC Coated Rigid Steel Conduit Fittings: Coating shall be 40 mil PVC on fittings and straps.
 - c. EMT Fittings:
 - 1) EMT steel conduit fittings shall be zinc-plated malleable iron or galvanized steel and meet Federal Spec. W-F-408.
 - 2) Mechanical type steel set screw or compression type connecting devices shall be used on EMT conduit connections.

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- 3) Insulating bushings shall be provided on EMT conduit stubs above ceiling. Insulated bushings shall be O-Z Type SBT, Arlington EMT Series, or approved equal.
 - 4) Expansion fittings shall be provided at building expansion joints and where required to compensate for thermal expansion and contraction. Expansion fittings shall be O-Z/Gedney Co. Type TX, Cooper Crouse-Hinds Type XJG, or approved equal.
- d. Flexible Metal Conduit Fittings: Flexible metal conduit fittings shall meet Federal Spec. W-F-406 and be of proper size and type to match raceway and box.
 - e. Liquidtight Flexible Metal Conduit Fittings: Liquidtight flexible metal fittings shall meet Federal Spec. W-F-406 and be of proper size and type to match raceway and box. Fittings shall provide positive seal against moisture and liquids.
 - f. Liquidtight Flexible Non-Metallic Conduit Fittings: These liquidtight connectors shall be of proper size and type to match raceway and box.

C. Manufacturers:

1. RMC, IMC and EMT steel conduit shall be products of Wheatland Tube Co., Allied Tube & Conduit Corporation, LTV (Republic Steel), Steelduct Conduit Products, Hylsa Tubular Products, Picoma Industries Inc., or approved equal.
2. RMC, EMT and IMC steel conduit fittings shall be products of RACO Inc., Midland-Ross (Steel City), Spring City Electrical Manufacturing Co., O-Z/Gedney Co., Allied Tube and Conduit Corp., or approved equal. EMT die-cast zinc alloy No. 7 fittings shall be manufactured by Bridgeport Fittings Inc. Conduit sealing bushings for watertight seal of wiring in IMC or RMC steel conduit shall be O-Z Gedney CSB Series, or approved equal.
3. Flexible metal conduit shall be products of American Flexible Conduit Company, Alflec Corp., Anaconda Metal Hose, or approved equal. Flexible metal conduit fittings shall be by Midland-Ross (Steel City), Appleton Electric Co., or approved equal.
4. Liquidtight flexible metal conduit shall be a product of Alflec Corp. (Ultratite), American Flexible Conduit Co. (Amer-Tite) Type UL, Electric-Flex Co. (Liquatite) Type L.A., Anaconda Metal Hose (Sealtite) Type UA, or approved equal. Liquidtight flexible metal conduit fittings with insulated throat shall be by Midland-Ross (Steel City), Appleton Electric Co., Harvey Hubbell Inc., Ideal, O-Z/Gedney Co., (Crouse-Hinds) Midwest Electric Manufacturing Corp, Bridgeport Fittings Inc., or approved equal.
5. Liquidtight flexible non-metallic conduit and fittings shall be manufactured by Carlon Electrical Products (Carflex), Alflec Corp., Harvey Hubbell (Polytuff-1), Thomas & Betts Corp. Type LTC (UltraFlex), RACO Inc. 6700 Series, or approved equal.
6. Air and noise sealing material shall be PERMAGUM manufactured by Virginia Chemical, Duct Seal by Panduit Corp., Blackburn/Holub of American Electric, or approved equal.
7. Rigid steel conduit threaded connections shall have T & B KoprShield, or approved equal, applied prior to screwing lengths together.

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8. Clamps and Supports:

- a. Rigid steel or IMC conduit beam clamps shall be O-Z/Gedney Co. UBC clamps, Appleton Electric Co. K-clamps, or approved equal.
- b. EMT 1/2 inch through 1 inch conduit clips to support conduit from angle iron, purlins or U-type channels shall be ERICO "Caddy Fasteners" or approved equal.
- c. Supports for conduits run on roofs shall be recycled rubber supports with strut manufactured by Cooper B-Line, Inc., or approved equal.

2.2 PULL AND JUNCTION BOXES

A. General:

1. Pull and junction boxes are not completely shown. Boxes for wiring to 600 volts shall be sized and installed where required in accordance with NEC. Boxes larger than code requirements shall be provided where wire or cable manufacturer requires larger bending radius than required by NEC and where taps or splices would be compressed by placement of the box cover plate. Pull and junction boxes shall have screw on removable cover mounting hardware shall be galvanized steel.
2. Pull and junction boxes shall be galvanized sheet steel and be suitable NEMA type to match environment of the box location. Boxes shall have continuously welded seams.
3. Pull boxes shall be installed in horizontal conduit runs of more than 100 ft. and in "power wiring" conduit runs with more than four (4) right angle bends or 360 degrees and in "voice/data" or "communication wiring" conduit runs with more than two (2) right angle bends or 180 degrees. Pull boxes shall be installed in vertical conduit runs for supporting conductors at intervals not exceeding requirements of NEC.
4. Pull or junction boxes enclosing normal and emergency circuits shall have full height and depth steel barrier plates for separation between each type circuit. Where pull or junction boxes enclose circuits of different voltages and the insulation of the wire of both circuits is not rated to meet that of the higher rated circuit a similar barrier plate shall be provided between the circuits.

B. Materials and Applications:

1. Dry Locations:

- a. Indoor feeder metallic boxes shall be constructed of minimum 14 gauge hot-dipped galvanized steel, cast or sheet aluminum with screwed on or hinged cover with locking latches. Cover plate screws shall be corrosion-resistant machine type.
- b. Indoor branch circuit metallic boxes used with EMT conduit shall be square, octagon or rectangular constructed of minimum 14 gauge hot-dipped galvanized steel, cast or sheet aluminum, and have knockouts on all sides. Cover plate screws shall be corrosion-resistant machine type.

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2. Outdoor and Indoor Wet Locations:
 - a. Feeder metallic boxes shall be UL listed watertight boxes. Boxes shall have gasketed and screw type covers, and have threaded connections that are watertight bolt-on hubs, sealing-locknuts or Scru-Tite hubs for RMC or IMC steel conduit. Cover plate screws shall be corrosion-resistant machine type.
 - b. Branch circuit metallic boxes used with RMC or IMC steel conduit shall be FS or FD cast type boxes. Boxes shall have threaded fittings and be weatherproof, raintight and dusttight with gasketed covers. Totally exposed boxes shall be UL listed watertight boxes.
3. Metallic boxes shall be UL listed watertight boxes. Boxes shall have gasketed screwed on type covers, and have threaded watertight cast or bolt-on hubs, sealing-locknuts, or Scru-Tite hubs for RMC steel or IMC conduit connections. Screws and other fasteners shall be nickel plated, or stainless steel to prevent corrosion. Cover plate screws shall be corrosion-resistant machine type.

C. Manufacturers:

1. Indoor metallic junction and pull boxes shall be manufactured by RACO, Queen Products Co., Wadsworth Electric Manufacturing Co., Hoffman Engineering Co., E.M. Wiegmann & Co. Inc., Fab-Con, Indquip Engineering Inc., or approved equal.
2. Outdoor and wet location metallic junction and pull boxes shall be manufactured by Killark Electric Mfg. Co., Appleton Electric Co., O-Z/Gedney Co., Crouse-Hinds Co., or approved equal.
3. Conduit sealing bushings shall be O-Z/Gedney Type CSB, Spring City, or approved equal.

PART 3 - EXECUTION

3.1 INSTALLATION OF CONDUIT AND TUBING

A. General (All Conduit and Tubing):

1. Cutting and Cleaning: Conduits shall be cut square, reamed and cleaned before installation. Before installing any wire in conduit, Contractor shall remove all water, condensation and obstructions that may have accumulated.
2. Ends: Ends of conduits shall be capped during rough-in to seal out moisture, plaster and dirt.
3. Damaged: Crushed or deformed conduits shall not be used.
4. Clearance and Vibration Isolation: Conduits shall be run at least 6 inch clear of steam and hot water pipes. Only flexible conduits shall come in contact with, or be attached to any electrical devices in piping or ductwork. Other conduits shall be mounted clear of piping and ductwork to avoid vibration transmission.
5. Grounding Bushings: Grounding bushings shall be used on RMC or IMC steel conduits containing feeders that enter metallic enclosures of switchgear, switchboards, motor control centers, panelboards, pull boxes and junction boxes. Grounding type bushings

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shall be bonded together with grounding wire terminated on equipment grounding bus or when equipment grounding bus is not provided to metallic enclosure to a self-tapping screw.

6. Sealing:
 - a. Air or Noise Seal: A minimum of 1 inch of sealing material shall be provided to prevent air movement and sound transmission via electrical conduits and wall boxes. Sealing material shall also be adequately placed in openings around conduit entering fan plenums to stop airflow. Where the conduit contains wiring, the sealing material shall be placed between interior wall of the conduit and the wire.
 - b. Raceway Exposed to Different Temperatures: Where conduit passes from area interior to exterior of a building or from a non-refrigerated area to a refrigerated area an air seal shall be provided to prevent movement of air within the conduit and the possible formation of condensation. Sealing shall be done by use of a C type (Condulet) conduit body or box placed in the horizontal runs at the wall penetration and sealing material approved by AHJ.
 - c. Fire and Smoke Seal: Holes cut by Contractor through smoke partitions, fire partitions or floors shall be sealed by Contractor. Sealant shall be of type specified in SLEEVES AND OPENINGS article in this Section 260500.
7. Aisles or Walkways: Conduits shall not be run across floor, immediately above floor or in manner that will provide hazard to people (e.g. tripping, head knocker, etc.). Conduit considered by Architect/Engineer to be mounted in manner hazardous to people shall be relocated by Contractor without cost.
8. Accessibility: Conduits shall not block ready access to equipment, devices or a room. This includes but is not limited to cover plates, lighting fixtures, valves, air mixing boxes, doors, ladders or exit scuttles where access may be required.
9. Conduit Supports: Conduit shall be securely fastened in place.
 - a. Single Conduit: Conduit supports for single runs shall be hung from dedicated electrical drop wire/rod appropriately fastened to the building structure to match loading. When single conduits are run above a ceiling and are not required to be seismic braced, they may be secured to properly hung wire or rod supports. Conduit shall be fastened to the wire/rod with ERICO Caddy Fasteners K Type or "multi-function" spring clips, or approved equal. Conduit wire drop supports above a suspended ceiling shall be fastened to the ceiling supports using ERICO Caddy EC311 independent electrical drop wire securing clip, or approved equal.
 - b. Multiple Conduit: Conduit supports for multiple conduit runs shall be U-type channel framing members fastened to the wall or a trapeze hanger consisting of a U-type channel attached to pair of threaded galvanized steel rods suspended from building structure above. Conduit shall be fastened to channel framing members with Caddy Fastener "Strut Clamps" or approved equal. U-type channel framing members and hardware shall be type specified in Section 261900, EQUIPMENT SUPPORTING DEVICES. Supports shall be rigid.
 - c. Seismic Requirements: Reference Section 262400 - VIBRATION AND SEISMIC CONTROL, Article "Installation of Conduit" for details.

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10. Homeruns: Where individual homeruns for wiring are shown on the drawings, Contractor shall not consolidate or group together wiring with other homeruns into a larger conduit and adjust wire size in accordance with NEC.

B. General (EMT, RMC, and IMC Steel Conduits):

1. Supports: EMT, RMC and IMC steel conduit shall be provided with galvanized steel straps, clamps, or hangers at a maximum spacing of 10 ft. for EMT and IMC, and 10 ft. to 20 ft. for RMC steel based on the conduit size in accordance with NEC. Conduits shall be fastened within 3 ft. of each box, cabinet or fitting. Conduits shall not be supported directly from ceiling T-bars, ceiling support rod hangers less than 3/16 inch, ductwork or piping, nor shall it be supported from any ductwork or piping supports that will transmit vibration.
2. Building Expansion Joints: Expansion fittings shall be provided in raceways at building expansion joints and elsewhere when raceways are required to compensate for thermal expansion and contraction. Indoor expansion fittings in steel conduit shall allow minimum of 4 inch movement (2 inch each direction). Deflection fittings shall be provided where required to compensate for linear expansion or contraction up to 3/4 inch and angular misalignment of up to 30 degrees. Fittings shall be installed under strict accordance with manufacturer's instructions.
3. Bends: Field-made bends in runs of conduit shall be made only with equipment intended for the purpose and shall not effectively reduce internal diameter. Bends on conduit runs between two (2) points of conduit termination shall not exceed 360 degrees total for "power wiring" or 180 degrees total for "voice/data" or "communications wiring". A pull box shall be installed between the two (2) points of a conduits termination for additional bending. PVC conduit bends, elbows and other fittings shall be capable of freely passing a ball that is 1/4 inch less in diameter than nominal bore of conduit. Long radius bends shall be provided where required to prevent violation of minimum bending radius of conductors as indicated by conductor manufacturer and allow easier pulling.
4. Joints and Couplings: RMC and IMC steel conduit joints shall be made with threaded fittings brought up snug and tight. EMT mechanical or compression fittings shall be properly fastened and tightened. PVC conduit joints shall be made using compatible fittings.
5. EMT steel shall be used for the following applications:
 - a. Conduit runs inside building run above ceilings and conduit stubs to above ceiling from wall outlets for voice and/or data wiring.
 - b. Conduit runs exposed in unfinished areas or concealed in finished areas inside building unless noted otherwise.

C. General (Flexible Metal and Liquidtight Flexible Metal Conduit):

1. Supports: Flexible metal and liquidtight flexible metal conduit shall be supported at maximum spacing of 4-1/2 ft. Conduits shall be fastened within 12 inch of each box or fitting. Conduit runs used for vibration isolation that are 3 ft. or less are not required to be supported.

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2. Grounding: Flexible metal and liquidtight flexible metal conduit shall be grounded using fittings UL listed for grounding. Grounding conductors shall be provided in flexible conduits where indicated and where circuit conductors are protected by overcurrent devices above 20 amperes and where they are longer than 6 ft.
3. Liquidtight flexible metal conduit connections to small transformers, motors, control instruments, control devices, transmitters, sensors, and other instruments shall be looped to allow water to drip off and to prevent vibration transmission.
4. Flexible metal conduit shall be used for following applications:
 - a. Conduit connections of at least 20 diameters in length to small fractional horsepower motors above accessible suspended ceilings or other dry locations.
5. Liquidtight flexible non-metallic conduit may be used for following applications:
 - a. Conduit connections to mechanical equipment located outside of building on roof may be liquidtight flexible non-metallic conduit.
 - b. Conduit shall also be used for wiring to 600 volts for control consoles, computer power supplies or I/O devices where conduit will not be subject to physical damage.
 - c. Conduit runs shall not exceed 6 ft. or be used in areas where conduits design temperature exceeds 140 deg. F. to -13 deg. F.

D. Indoor Finished Areas:

1. Concealed Conduit and Wire: Conduit and wire in finished areas shall be concealed above ceilings. Conduit and wire in finished areas of existing construction shall be concealed above accessible ceilings. However, in areas with non-accessible ceilings, metal-clad cable of appropriate type may be used for fishing circuit wiring from one area to another through the ceiling cavity.
2. Above Ceiling:
 - a. Contractor shall coordinate conduit runs above ceilings with ductwork and piping. Conduit runs shall not be installed above suspended lay-in ceilings in such a manner as to prevent removal of ceiling tile. Supports shall be in accordance with NEC.
 - b. Conduit Stubs: EMT, RMC or IMC steel conduit run from device boxes in wall and stubbed above accessible ceilings shall have insulated bushing on stub end and be located in accessible location above ceiling.
3. Exposed Conduit: EMT, RMC or IMC steel conduit shall be concealed except in mechanical rooms, electrical closets, unfinished communication rooms, manufacturing areas, elevator penthouses or machine rooms.

E. Indoor Unfinished Area Conduit Work:

1. Exposed conduit shall be run parallel with or perpendicular to building structural members, however, obstructions may be cleared by use of bends, offsets, and where

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necessary, junction and pull boxes. Conduits mounted on walls shall be mounted plumb and in a neat and orderly manner.

2. Conduits may be run exposed in unfinished areas such as mechanical rooms, electrical closets, communications rooms, storage areas, elevator penthouses and machine rooms.
3. Escutcheon plates shall be provided for exposed conduit passing through walls, floors and ceilings. Plates shall be nickel plated of split ring type and of size to match conduit. Where plates are provided for conduit passing through sleeves which extend above the floor surface, provide deep-recessed plates to conceal sleeves.

F. Indoor Wet Location Conduit:

1. Exposed conduit shall be run parallel with or perpendicular to building structural members, however, obstructions may be cleared by use of bends, offsets, and where necessary, junction and pull boxes. Conduits mounted on walls shall be mounted plumb and in a neat and orderly manner.
2. Exposed wall-mounted steel conduit and fittings shall be mounted on appropriate U-type channel framing member or other similar support providing a minimum 3/4 inch air space between it and wall.
3. Liquidtight flexible metal conduit shall be used for following applications:
 - a. Mechanical Equipment Connections in Wet Locations: Electrical raceway connections to mechanical equipment in equipment rooms, and connections to mechanical equipment outside the building shall be made with liquidtight flexible metal conduit.
 - b. Motor Transformer and Generator Connections: Flexible conduit connections to motors, transformers and generator(s) shall be made with liquidtight flexible conduit at least 20 diameters in length.
 - c. Control Instruments, Control Devices, Transmitters, and Sensors Connections: Control instruments, control devices, transmitters and sensors requiring low voltage signal cable or 120 volt power supply shall be made with liquidtight flexible metal conduit with minimum length of 12 inch and a maximum length of 24 inch. Minimum size conduit shall be 3/8 inch. Circuits less than 50 volts can be run with open cables supported in workman-like manner in accordance with NEC.
 - d. Conduit runs for furniture feeds from poke-through floor boxes shall be with 6 ft. long liquidtight flexible metal conduit with appropriate wiring.

G. Outdoor Above Ground Conduit Work:

1. Conduit shall be rigidly supported.
2. Conduits (rigid or IMC steel) run across existing roofs shall be run on Lexan polycarbonate stand or polyethylene foam (Ethafom) with galvanized strut at even intervals not exceeding 8 ft. On built up roofs, loose aggregate shall be removed in area below supports. Supports shall be fastened to roof with pitch. Conduit clamp hardware fastened to support shall not penetrate the roof.
3. Joints at fittings and boxes shall be adequately tightened and be watertight.

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4. Nicks, scratches, rusty spots or scrapes on RMC or IMC steel conduit or supports shall be thoroughly cleaned and repainted with galvanize paint or other corrosion resistant finish.
5. RMC or IMC steel conduit supporting clamps and hardware shall be stainless or galvanized steel. Clamps or hardware with nicked, scraped or rusty surface shall be replaced or adequately cleaned and repainted with galvanize paint.
6. Sleeves: Conduit entering or leaving building or structure through outside wall or roof shall be run through sleeves. Sleeves shall be sealed watertight between sleeve and wall or roof and between conduit and sleeve. Wiring inside conduit shall be sealed watertight. Reference SLEEVES AND OPENINGS article in Section 260500 for additional details.
7. These type raceways shall be used for following applications.
 - a. Conduit runs outside of building exposed to weather or indoor wet/hosedown areas shall be RMC or IMC.
 - b. Exposed conduit located in an area from floor to 8 ft. above floor in mechanical equipment rooms, electrical rooms, and loading docks shall be either IMC or RMC.
 - c. In other rooms or areas where conduit may be exposed to possible physical damage (i.e. stage, kitchen, etc.), the conduit shall be RMC from the floor to 8 ft. above the floor.

3.2 PULL AND JUNCTION BOX INSTALLATION

- A. Mounting and Accessibility: Wiring and connectors inside boxes or box interiors in empty boxes shall be totally accessible by removing cover plate. Necessary clearance shall be provided between box and other conduit, boxes, pipes, or ductwork to allow pulling of wire or making of wiring junctions. Pull and junction boxes shall be concealed in finished areas. Interiors of pull and junction boxes in conduit runs concealed above ceilings shall be accessible by removing ceiling tile of accessible ceilings, be located behind access panels in inaccessible ceilings or be mounted with cover plate flush in the ceiling. Pull and junction boxes in walls shall have flush-mounted cover plates.
- B. Supports: Boxes shall be appropriately secured in accordance with NEC.
- C. Outdoor or Indoor Wet Locations:
 1. Surface-mounted boxes shall be mounted on U-type channel framing member of other support providing a minimum 3/4 inch air space between it and wall.
 2. Conduit entries for outdoor or wet location mounted boxes shall be threaded and watertight. Conduit sealing bushings shall be installed at boxes to provide watertight seal around cables when possible. When this is not possible Duct Seal, Permagum, or approved equal, shall be placed around all conductors in conduit to provide watertight seal.
- D. Identification: Boxes for Photovoltaic and wind system(s) shall also be appropriately labeled. Reference Section 261950 - ELECTRICAL IDENTIFICATION for additional details.

END OF SECTION 261300

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DIVISION 26 – ELECTRICAL WORK

SECTION 261900 – ELECTRICAL EQUIPMENT SUPPORTING DEVICES

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SECTION 261900 - ELECTRICAL EQUIPMENT SUPPORTING DEVICES

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL SUPPORTING DEVICE REQUIREMENTS

- A. This section is intended to cover equipment supporting devices and their installation applicable to Contractor's works.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Equipment, devices or supports manufactured using metal or having metal surfaces, that require cutting in the field shall have cut surfaces or edges smoothed and refinished with appropriate primer and finish to match surface prior to being cut.
- D. Outdoor and Wet Locations: Where the term outdoor is used section of specifications it shall also be defined as indoor wet location. Devices or equipment specified as outdoor shall meet code requirements for wet locations and shall be applicable for use in indoor wet locations.
- E. Equipment Series, Model or Part Numbers: Manufacturer's series, model or part numbers listed in this section are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be superseded, it shall be understood that newest equivalent series, model or part shall be furnished.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install equipment and supporting devices as specified and indicated.

1.4 DESCRIPTION OF SYSTEMS

- A. Equipment supporting devices shall be provided as called for in this specification section.

1.5 SUBSTITUTIONS

- A. See Section 260100.

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1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100.
- B. Reference Section 262400 - VIBRATION AND SEISMIC CONTROL for additional shop drawings requirements for supporting devices providing vibration and seismic restraints.

PART 2 - PRODUCTS

2.1 EQUIPMENT SUPPORTING DEVICES

- A. General:
 - 1. Contractor shall verify the adequacy of the building supports or structure prior to hanging electrical equipment.
 - 2. Contractor shall provide appropriate anchors, supports and hardware to match the building structure and type and weight of the electrical equipment. Prior to installing fasteners and anchor bolts, the Contractor shall verify their static load limits, torque limits, hole size and depth, and allowable working loads in tension and shear with the manufacturer of the fasteners and anchors.
 - 3. Contractor shall coordinate location of anchors and weight of the equipment to be installed with equipment manufacturer's installation drawings. Contractor shall install equipment with supports provided by the equipment manufacturer in accordance with manufacturer's installation drawings. Equipment and devices mounted on exterior walls or in damp or wet locations shall be mounted on U-type channel framing members to allow air circulation and help prevent rusting.
 - 4. Coordination: Reference Section 260100, COORDINATION article for additional coordination requirements.
 - 5. Equipment Supported Overhead:
 - a. General: Anchors, support rods and mounting hardware for equipment hung from overhead shall be of appropriate size and type to match overhead structure with minimum load safety factor of 4.
 - b. Load and Hangers: Trapeze type supports shall be used for hanging loads such as transformers, or large size or quantity of conduit runs. Individual conduits may be hung from structure above with individual anchors or beam clamps and support rods with single pipe hangers.
 - c. Equipment Interference: Contractor shall provide additional trapeze type supports consisting of horizontal U-type channel framing members hung from rods anchored to building structure for spanning any interfering ductwork or piping.
 - 6. Wall Hung Surface-Mounted Equipment:
 - a. General: Anchors, supports and mounting hardware for wall hung surface-mounted equipment shall be of appropriate size and type to match wall construction with minimum load safety factor of 4.

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- b. Drywall Partitions:
 - 1) Heavy loads such as cabinets that are to be mounted on drywall partitions shall either be fastened across multiple wall studs or be mounted to U-type channel framing members that are anchored to multiple wall studs.
 - 2) Conduits and Boxes: Rows of conduits and associated boxes shall be fastened to U-type channel framing members anchored to wall studs. Individual conduits and boxes may be fastened directly to wall studs.
 - c. Concrete and Masonry Walls:
 - 1) Surface Mounted Conduits and Boxes: Rows of conduits and associated boxes shall be fastened to U-type channel framing members anchored to the wall with appropriate anchors. Individual conduits and device boxes may be fastened directly to the wall.
 - 2) Surface Mounted Panelboards and Cabinets: Surface mounted panelboard backcans and cabinets located on concrete or masonry walls shall not be directly fastened to the walls but shall be mounted on U-type channel framing members anchored to walls with appropriate anchors.
 - 3) Surface-Mounted Motor Starters and Disconnect Switches: Metallic motor starters and disconnect switches located on concrete or masonry walls shall be fastened to walls on U-type channel framing members anchored to walls with appropriate anchors.
7. Floor-Mounted Equipment:
- a. General: Anchors and bolts for floor-mounted equipment shall be of appropriate size and type to match type floor construction with minimum shear load safety factor of 4.
 - b. Concrete Housekeeping Pad: Floor mounted inverters shall be anchored to a concrete housekeeping pad.
 - c. Racks, Stands and Vertical Supports:
 - 1) Panelboards, motor starters, disconnect switches designed for wall mounting may be floor mounted on field constructed or equipment manufacturer supplied racks or stands. Racks, stands or vertical supports shall be rigidly constructed and anchored.
 - 2) Field Constructed Supports: Field constructed vertical supports shall be freestanding and fastened to the floor or be fastened to the floor and the overhead structure. Supports shall consist of a minimum of two (2) vertical metal framing members and two (2) horizontal braces between the two (2) vertical members. Also provide two (2) horizontal metal framing members at the floor, or at the floor and the overhead structure as appropriate. Vertical and horizontal supports, braces, as well as, the floor and overhead supports shall be U-type channel metal framing members of appropriate size and strength. All framing members shall be rigidly attached to each other with appropriate hardware and angle fittings. The entire support assembly

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shall be anchored to the building structure at a minimum of four (4) locations.

- 3) Equipment Manufacturer's Racks or Stands: Manufacturer's racks and stands shall be adequately braced and anchored in accordance with manufacturer's installation instructions.

B. Materials and Applications:

1. Indoor Dry Location U-type Channel Metal Framing Members: Indoor U-type channel metal framing members for supporting conduits, panelboards, motor starters, disconnect switches, cabinets, small transformers, and boxes shall be electro-galvanized steel or have baked acrylic enamel paint applied by electro deposition.
2. Outdoor or Indoor Wet Location U-type Channel Metal Framing Members: Outdoor or wet location U-type channel metal framing members for supporting conduit, panelboards, motor starters, disconnect switches, boxes, or, transformers, shall be hot-dipped galvanized after fabrication unless otherwise indicated.
3. Anchors:
 - a. Interior or Exterior Masonry Walls: Provide anchors designed to match type wall construction and to withstand tension and shear loads with minimum safety factor of 4.
 - b. Interior Dry Wall: Provide toggle anchors designed to match wall type construction and to withstand tension and shear loads with minimum safety factor of 4.
 - c. Interior or Exterior Concrete Walls: Provide expansion or adhesive type anchors designed to match type wall construction and to withstand tension and shear loads with minimum safety factor of 4.
 - d. Concrete Floor: Provide expansion anchors designed to match concrete floor construction and to withstand shear loads with minimum safety factor of 4.
4. Beam Anchors and Clamps:
 - a. Concrete Beam Anchors: Provide expansion anchors designed to match concrete beam or joist construction and load in pounds placed on the anchor in tension or shear with minimum safety factor of 4.
 - b. Steel Beam Clamps:
 - 1) Beam clamps for rod supports shall be adjustable type and match beam size, hanger rod diameter and loading with minimum safety factor 4. Beam flange clamps shall be approved for seismic where available.
 - 2) Beam clamps for channel metal framing members shall match beam, channel framing member and loading with minimum of safety factor 4.
5. Support Rods: Vertical support rods shall be galvanized and threaded. Support rods shall be designed to match load in pounds placed in tension and shear with minimum safety factor of 4.

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6. Hardware: In general, threaded rods, nuts, bolts, screws, and washers shall have galvanized or nickel-plated finish to prevent rusting. Hardware in indoor wet locations or outdoors shall be stainless steel. Mounting hardware shall have minimum load safety factor of 4.
- C. Manufacturer: None of this equipment or anchors shall be used for seismic support unless approved by the professional engineer employed by the vibration and seismic restraint manufacturer specified in Section 262400.
1. U-Type Channel Metal Framing Members: Indoor and outdoor U-type channel metal framing members shall be by Unistrut, Building Systems Division of GTE Products Corp.; B-Line Systems Inc. (Strut Systems); Allied Tube and Conduit (Power-Strut); American Electric, FL Industries (Superstrut) or (Kindorf), or approved equal.
 2. Anchors:
 - a. Masonry adhesive anchors from 3/8 inch to 3/4 inch shall be HILTI Type HIT, or approved equal. Toggle anchors of appropriate size and type are allowed for hollow masonry (concrete block).
 - b. Concrete expansion anchors in sizes from 1/4 inch to 3/4 inch shall be HILTI Type HDI, or approved equal. Concrete adhesive anchors in sizes from 3/8 inch to 1-1/4 inch shall be HILTI Type HVA, or approved equal.
 - c. Self-drilling anchors for hollow block and brick shall be manufactured by Phillips (Red-Head), Ramset Fastening Systems (RamDrill), or approved equal.
 - d. Self-drilling anchors for concrete shall be manufactured by Philips (Red-Head, Ramset Fastening Systems (RamDrill), Greenlee Textron (Hanger Mate), or approved equal.
 - e. Self-drilling anchors (E-Z Toggle) for drywall or gypsum wallboard shall be manufactured by ITW Buildex, or approved equal.
 - f. Anchor bolts, toggles, etc., shall be HILTI Corp., ITT Ho-Lub; Buildex Tapcon Anchors a Division of Illinois Tool Works Inc., Metallics Inc. of Bristol, Conn., Ramset Fastening Systems of East Alton, IL, or approved equal.
 3. Steel Beam Clamps: Beam clamps shall be American Electric FL Industries, Steel City or Kindorf; Unistrut, Building Systems Division of GTE Products Corp; Minerallic Electric Co., ERICO Fastening Products, Kee Industrial Products Inc. (Lindapter), B-line Systems Inc., or approved equal.
 4. Conduit support straps, clips and hangers shall be manufactured by Minerallic Electric Co. or ERICO (CADDY Fasteners), or approved equal. Pipe hangers shall be manufactured by Grinnell Inc., B-Line, or approved equal.

PART 3 - EXECUTION

3.1 EQUIPMENT SUPPORTING DEVICE INSTALLATION

- A. Where specifications include Section 262400 - VIBRATION AND SEISMIC CONTROL all anchors shall meet that section.

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- B. Provide correct size holes for wall, partition and beam anchors. Anchor bolt holes drilled in reinforced concrete beams or concrete joists shall avoid cutting reinforcing bars.
- C. Provide U-type channel metal framing members of correct size, length, type and strength to support equipment intended to be mounted to or hung from the channel framing member. Channel metal framing members shall be mounted plumb and level.
- D. Supports and electrical equipment shall be securely fastened in place. Electrical equipment shall not be hung from piping, ductwork or from hangers supporting piping or ductwork. Supports shall be designed and arranged in such manner as to avoid accumulation of dirt and dust.
- E. Unused holes for anchors in walls, partitions or beams shall be filled with appropriate material and be finished smooth.
- F. Raw edges of U-type channel metal framing members that require cutting and other outdoor supporting hangers, brackets and channels shall be cleaned and sharp edges ground smooth. Supports shall then be wiped clean and be painted with primer and finish coat. Supports of galvanized steel shall be refinished with ZRC Chemical Products Co. "Cold Galvanizing Compound" for matching a dull finish or Brite Products "Brite Zinc" galvanizing compound for matching a bright or hot-dip finish.

END OF SECTION 261900

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SECTION 261950 - ELECTRICAL IDENTIFICATION

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS govern work under this specification section.

1.2 GENERAL IDENTIFICATION REQUIREMENTS

- A. This section is intended to cover identification of electrical devices and equipment and their installation applicable to the Contractor's work.
- B. Contractor shall include labor and material for furnishing and installing proper identification of electrical work as specified or indicated.
- C. Contract drawings and specification are complementary each to the other, and what is called for by one shall be as binding as if called for by both.
- D. Unless otherwise indicated, identification by name or abbreviation shall be consistent with that shown on the drawings.
- E. All identification devices for each category such as nametapes, nameplates, labels, and warning signs shall be by a single manufacturer, be of the same size, type and coloring and have the same style lettering to provide consistency.

1.3 SCOPE OF WORK

- A. Electrical devices and equipment shall have nameplates, nametapes, labels or other identification as specified in this section.

1.4 DESCRIPTION OF REQUIRED IDENTIFICATION

- A. See PART 2 of this specification section.

1.5 SUBSTITUTIONS

- A. See Section 260100.

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PART 2 - PRODUCTS

2.1 NAMEPLATES

- A. Nameplates shall be placed on major electrical distribution equipment.
- B. Nameplates shall be approximately 1 inch high x 1/16 inch thick laminated plastic with beveled edges. Nameplates shall have white surface and black core to provide black lettering when engraved. After being engraved nameplates shall be mechanically attached to equipment with screws.
- C. Engraved lettering shall be a minimum 1/4 inch high and spacing between words of approximately 3/16 inch to avoid crowding. Normally, descriptions will require only a single line of lettering centered on nameplate. Where descriptions require two (2) or more lines of lettering, the description shall be separated and centered on nameplate. Multiple lines of lettering shall be separated from each other by approximately a 3/16 inch high space. Lettering shall be minimum 1/32 inch wide.
- D. Identification: Nameplates generally shall identify equipment with nomenclature corresponding to marking indicated on drawings and include system voltage. Nameplates for individual switches, breakers or motor starters shall indicate description of load served. Reference each section of specifications for additional detailed description.

2.2 NAMETAPES

- A. Nametapes shall be placed on electrical equipment, cabinets and boxes.
- B. Nametapes shall be 1/2 inch wide, black background pressure-sensitive tape similar to Rotex Dymo Tape, or approved equal. Identification shall indicate in white embossed lettering.
- C. Identification: Nametape lettering shall identify system or equipment by name or abbreviation and include circuit identification where applicable.

2.3 LABELS

- A. Labels shall be placed on cover plates of junction and pull boxes containing wind/PV system wiring.
- B. Labels shall be pressure-sensitive vinyl approximately 2-1/4 inch x 9 inch by EMED Co. Inc., Carlton Industries, Inc., LEM Products, SETON Nameplate Co., or approved equal. Labels shall have black letters on orange background.

2.4 WIRE MARKERS

- A. Markers shall be placed on control, monitor and signal wiring at all terminations in control, monitor or signal devices or equipment. Wire identification markers shall be pressure-sensitive

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type with surface resistive to heat 250 deg. F., abrasion, oil and dirt. Markers shall be by W.H. Brady Co. (Bradypack), Thomas & Betts (E-Z coder), Ideal, or approved equal.

2.5 COLOR-CODED TAPE

- A. Tape shall be 3M Company "Scotch 35" vinyl plastic electrical tape.
- B. Conductors: Conductor color-coded tape shall be pressure-sensitive 1/2 inch wide of color specified in Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS).

2.6 DIRECTORY CARD

- A. New directory cards shall be provided for each branch circuit panelboard having new circuit breakers. Utilize correction fluid or re-type a new card, scribbling out old designations or writing in card margins is unacceptable. New cards, when required, shall be on minimum 100 lb. print stock.

2.7 WARNING SIGNS

- A. Signs shall be pressure sensitive type with appropriate lettering. Signs shall be produced by Emed Co. Inc., Seton, Lab Safety Supply Inc., or approved equal.

PART 3 - EXECUTION

3.1 EQUIPMENT IDENTIFICATION

- A. General: Surface to which nametapes, nameplates or labels are to be applied shall be cleaned prior to their installation. Nameplates, nametapes and labels shall fit flush up against surface. Nameplates, nametapes and labels shall be centered and be square with equipment edges.
- B. Nameplates:
 - 1. Major equipment, such as switchgear, unit substations, transformers, motor control centers, panelboards shall be provided with nameplates. Each fusible switch, or circuit breaker on switchgear, switchboards, motor control centers shall be provided with an engraved nameplate. Panelboards shall have additional special nameplates in accordance with Section 264000, PANELBOARD INSTALLATION article.
 - 2. Each fusible switch or circuit breaker on switchgear, switchboards, panelboards without doors shall be provided with a nameplate.
 - 3. Disconnects in Wet Locations: Loose mounted outdoor or indoor wet location disconnect switches shall be provided with nameplates not nametapes.
- C. Nametapes:
 - 1. Unless otherwise indicated, loose-mounted indoor dry location disconnect switches shall be identified with nametapes.

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2. Nametapes shall be used on junction and pull box cover plates too small for attachment of labels.

D. Labels:

1. Junction and Pull Boxes: Labels shall be placed on junction and pull box cover plates for wind/PV systems. Reference paragraph C.2. above for cover plates too small for labels.

E. Wire Markers: Wire identification markers shall be placed on wires to provide easy identification of wiring. Wires shall be identified in accordance with equipment wiring diagrams furnished by equipment supplier.

F. Color-Coded Tape:

1. Conductor: Each conductor of a feeder shall be color coded its entire length or have a minimum of two (2) full turns of 1/2 inch pressure sensitive color-coded tape as specified in Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS) article. Tape shall be applied on conductors between 2 and 3 inch from each terminal end and on conductors inside each junction box or pull box.

G. Panelboard Directory:

1. New typewritten branch circuit directory cards shall be inserted within cardholder in panelboard. Contractor shall fill-in directory cards by typing Owner's final room name and identifying number as well as load description. Examples: Off. 312 Ex. Fan; Corr. 374 EWC; Stor. 963 Ltg.; Off. 731 Recept.; Tlt. 884 HTR. Room or area names and numbers shown on plans were used for design purposes only. Contractor shall verify final room or area names and numbers to be typed on each directory with the Owner.
2. Where loads cannot be identified with a specific room, a more complete load description shall be typed.
3. Panelboard "designation" used in drawing notes shall be typed at top of each directory card.

3.2 MANUFACTURER'S NAMEPLATES

- A.** Cabinets, disconnect switches, circuit breakers, panelboards shall be equipped with legible and visually accessible nameplates giving voltage and essential characteristics, such as horsepower, wattage or current as required by ANSI or NEMA standards.

END OF SECTION 261950

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SECTION 263100 - SOLAR WIND/PV SYSTEM

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL SYSTEM REQUIREMENTS

- A. This section is intended to cover Wind/PV systems and equipment and their installation applicable to the Contractor's work.
- B. Contractor shall include all labor, and material for the complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Contract drawings and specifications are complementary each to the other, and what is called for by one shall be as binding as if called for by both.
- D. Equipment Storage and Protection: In general, equipment shall be stored in sheltered clean, dry area. If equipment must be stored in cool, damp areas, heaters shall be provided to keep equipment dry. Contractor shall protect special system equipment from moisture until final acceptance by Owner. Rusted areas on equipment enclosure shall be cleaned, prime painted and receive appropriate finish coat. Equipment or components of equipment receiving moisture or water damage shall be replaced with new equipment or components at Contractor's expense. Until final observation equipment bus bars, terminals and other internal components shall be protected by Contractor from paint, plaster, cleaners, abrasives, dust and spray by providing appropriate covers.
- E. Seismic Requirements: Wind/PV equipment shall be installed to prevent lateral movement and uplifting due to seismic forces. Seismic anchors shall meet the requirements in Section 262400 - VIBRATION AND SEISMIC CONTROL.
- F. Guarantee: Guarantee shall be as required in Section 260100, GUARANTEE article except as revised by specific articles on equipment specified in this section.
- G. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part number listed in this section articles are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be obsolete or superseded, it shall be understood that newest equivalent series, model or part shall be furnished.

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H. Manufacturer's Field Service:

1. Service Personnel: The Wind/PV manufacturer shall directly employ a nationwide service organization, consisting of factory-trained field service personnel dedicated to the startup and maintenance of Wind/PV systems with their associated equipment and controls. The manufacturer shall provide a national dispatch center to coordinate field service personnel schedules. One toll-free number shall reach a qualified support person 24 hours/day, 7 days/week, 365 days/year.
2. Replacement Parts Stocking: Recommended spare parts shall be fully stocked by local field service personnel with back-up available from national parts center and the manufacturing location. The national parts center Customer Support Parts Coordinators shall be on-call 24 hours a day, 7 days a week, 365 days a year for immediate parts availability. Parts from the national parts center shall be shipped within 24 hours and delivered to the customer's site within 48 hours.
3. Wind/PV Maintenance Training: Maintenance training courses for the Owner's employees shall be provided by the Wind/PV manufacturer. This training is in addition to the basic operator training conducted as a part of the system startup.
 - a. The training course shall cover Wind/PV theory, location of subassemblies, safety, and operational procedures. The course shall include DC-to-AC inversion techniques as well as control and metering. Troubleshooting and fault isolation using alarm information and internal self-diagnostics shall be stressed.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and/or install and provide power for the following special systems equipment as indicated.
- B. Wind/PV Systems:
 1. Flat photovoltaic tiles
 2. Tilted photovoltaic panels
 3. Wind turbine
 4. Combiner box
 5. DC to AC inverter
 6. Metering equipment

1.4 DESCRIPTION OF SYSTEMS

- A. Following is general description of required Wind/PV systems equipment and devices:
 1. Wind/PV System: Wind/PV system shall be grid tied to the electrical utility grid system with existing building electrical distribution system and disconnect from distribution system upon interruption of the utility power.

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1.5 SUBSTITUTIONS

- A. See Section 260100.
- B. Substitutions shall also meet any additional requirements specified in this section under PART 2 - PRODUCTS.
- C. Space Allocation: Both physical and working space allocation indicated for Wind/PV equipment is based on first-named manufacturer. In event physically larger equipment is furnished, Manufacturer shall be responsible for making detailed installation drawings of equipment in an organized manner to match the allocated space prior to shipping any equipment.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100. Shop drawing submittals shall include but not be limited to following:
 - 1. Wind/PV System:
 - a. Flat photovoltaic tiles with mounting hardware
 - b. Tilted photovoltaic panels with mounting hardware
 - c. Wind turbine with mounting hardware
 - d. System combiner box
 - e. DC to AC inverter
 - f. Metering equipment
 - g. Cables and connectors
 - h. Reference Article 2.1 Paragraph A.5. "Submittals" for additional details.

PART 2 - PRODUCTS

2.1 PACKAGED WIND/PV SYSTEM

- A. General:
 - 1. Summary: This specification defines the electrical and mechanical characteristics and requirements for a grid tied Wind/PV system.
 - 2. Standards: The Wind/PV shall be designed in accordance with the applicable sections of the current revision of the following documents. Where a conflict arises between these documents and statements made herein, the statements in this specification shall govern.
 - a. NETA-ATS
 - b. NFPA-70
 - c. UL 1703 - for flat plate photovoltaic modules and panels
 - d. UL 1741 - for inverters, converters and controllers
 - e. IEEE 929 - recommended practice for utility interface of PV systems
 - f. IEEE 1262

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- g. IEEE 1547
- 3. System Description:
 - a. Design Requirements - Wind/PV System:
 - 1) Voltage: Output voltage specifications of the Wind/PV shall be 277/480 volts, 3 phase, four-wire-plus-ground.
 - 2) Output Load Capacity: Specified output load capacity of the Wind/PV shall be as indicated on Bid Submittal for each Option and Base Bid.
 - b. Modes of Operation: The Wind/PV shall be designed to operate as an electrical utility grid tie system to reduce the electrical utility demand of the building.
 - 1) Normal: The AC load is continuously supplied by the Wind/PV inverter. The Wind/PV system supplies DC power to the inverter which supplies AC power to existing electrical distribution system.
 - 2) Utility Outage: Upon failure of utility AC power, the AC load supplied by the inverter is to be disconnected to interrupt power to the building until restoration of the utility AC source.
- 4. Environmental Conditions: The Wind/PV shall be able to withstand the following environmental conditions without damage or degradation of operating characteristics:
 - a. Operating Ambient Temperature:
 - 1) Wind/PV Module: -20 deg. F. to 120 deg. F.
 - 2) Inverter: 32 deg. F. to 120 deg. F.
 - b. Relative Humidity: 0 to 95 percent, non-condensing.
 - c. Altitude:
 - 1) Operating: To 6600 ft. (2,000 M) above Mean Sea Level.
 - 2) Storage/Transport: To 40,000 ft. (12,200 M) above Mean Sea Level.
- 5. Submittals: Submittals shall include:
 - a. System configuration with single-line diagrams.
 - b. Functional relationship of equipment including weights, dimensions, and heat dissipation.
 - c. Descriptions of equipment to be furnished, including deviations from these specifications.
 - d. Size and weight of shipping units to be handled by Installing Contractor.
 - e. Detailed layouts of power and control connections.
 - f. Detailed installation drawings including all terminal locations.
 - g. Distribution cabinet details on size, quantity and type circuit breakers.

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- h. Submittals upon Wind/PV system delivery shall include:
 - 1) A complete set of submittal drawings.
 - 2) One instruction manual that shall include a functional description of the equipment with block diagrams, safety precautions, instructions, step-by-step operating procedures and routine maintenance guidelines, including illustrations.
- 6. Warranty: The Wind/PV system manufacturer shall warrant the system against defects in materials and workmanship for 12 months after the date of Substantial Completion of the work under this contract. Starting date for the warranty shall be the date of Substantial Completion of the work under this contract.
- 7. Quality Assurance:
 - a. Manufacturer Qualifications: A minimum of 5 years experience in the design, manufacture, and testing of Wind/PV systems is required. The system shall be designed and manufactured according to world class quality standards. The manufacturer shall be ISO 9001 certified.
 - b. Factory Testing: Before shipment, the manufacturer shall fully and completely test the system to assure compliance with the specification. These tests shall include operational discharge and recharge tests on at least a 1 minute battery plant to assure guaranteed rated performance.
 - c. Installer Qualifications: The installer of the Wind/PV systems shall have installed a minimum of 5 similar systems and be trained and approved by the Wind/PV system manufacturer.

B. Fabrication:

- 1. Materials: All materials of the Wind/PV system shall be new, of current manufacture, high grade and free from all defects and shall not have been in prior service except as required during factory testing.
- 2. Wiring: Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code (NFPA 70). All bolted connections of bus bars, lugs, and cables shall be in accordance with requirements of the National Electrical Code (NEC) and other applicable standards. All electrical power connections are to be torqued to the required value and marked with a visual indicator. Provision shall be made for power cables to enter or leave from the top or bottom of the Wind/PV cabinet.
- 3. Grounding: The AC output neutral shall be electrically isolated from the Wind/PV chassis. The Wind/PV chassis shall have an equipment ground terminal. Provisions for local bonding shall be provided.

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C. Components:

1. Flat Photovoltaic Roof Tile System:

- a. System to lay flat on existing roof in areas indicated on drawings as required to allow window washing support equipment cables to be routed on system from window washing support system to roof perimeter.
- b. System to allow for unobstructed roof drainage to existing roof drains and not interfere with roof operation or maintenance.
- c. System to include interlocking hardware to secure modules without roof attachments. If roof attachments or penetrations are required they are to be provided and sealed in accordance with existing roof manufacturer's requirements to maintain existing roof warranty.
- d. System components are to be corrosion resistant.
- e. System to weigh less than 5lb/ft².
- f. System to have a wind resistance of 140 mph.
- g. System to provide minimum of 15 peak Watts/ft².
- h. System to have temperate rating of -40 deg. F. to 185 deg. F. (-40 deg. C. to 85 deg. C.)
- i. System to have impact resistance of 1 inch hail at 52 mph (23 m/s)
- j. System to resist front and back wind load of 50 psf (24.5 kg/m²)
- k. System to be provided with 20 year warranty.

2. Tilted Photovoltaic Panel System:

- a. System to include photovoltaic panels mounted at a 10 degree tilt to increase system efficiency in areas designated on drawings.
- b. System to allow for unobstructed roof drainage to existing roof drains and not interfere with roof operation or maintenance.
- c. System to include interlocking hardware to secure modules without roof attachments. If roof attachments or penetrations are required they are to be provided and sealed in accordance with existing roof manufacturer's requirements to maintain existing roof warranty.
- d. System components are to be corrosion resistant.
- e. System to weigh less than 5lb/ft².
- f. System to have a wind resistance of 140 mph.
- g. System to provide minimum of 15 peak Watts/ft².
- h. System to have temperate rating of -40 deg. F. to 185 deg. F. (-40 deg. C. to 85 deg. C.)
- i. System to have impact resistance of 1 inch hail at 52 mph (23 m/s)
- j. System to resist front and back wind load of 50 psf (24.5 kg/m²)
- k. System to be provided with 20 year warranty.

3. Wind Turbine System:

- a. System to include three (3) vertical axis wind turbines rated for minimum of 2kW each.

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- b. System to be installed on three (3) structural elevator/stairwell penthouses as shown on drawings.
 - c. System to allow access to window washer tie-off system and unobstructed roof drainage off each penthouse.
 - d. System to include support components and to be attached to penthouse roof structure as required in accordance with manufacturer. All roof penetrations are to be sealed as required by existing roof manufacturer to maintain existing warranty.
 - e. All system components are to be corrosion resistant.
 - f. Each penthouse wind turbine with supports to weight less than 200 lbs.
 - g. System to be rated for wind speeds up to 90 mph.
 - h. System to have temperature rating of -40 deg. F. to 185 deg. F. (-40 deg. C. to 85 deg. C.)
 - i. System to have impact resistance of 1 inch hail at 52 mph (23 m/s)
 - j. System to be provided with 10 year warranty.
4. DC Combiner Box:
- a. Each Wind/PV system to be provided with separate DC power combiner box with overcurrent protection and disconnect rated at 600 VDC for each string of system.
 - b. Each combiner box to be provided with surge arrest device.
5. Inverter:
- a. Each inverter shall be certified to UL 1741 Standards by a Nationally Recognized Testing Laboratory (NRTL).
 - b. Each wind and PV system to be provided with separate inverter dedicated to system.
 - c. Each inverter to be sized to support 125 percent of the rated kW output of wind turbines or photovoltaic panels in system.
 - d. Each inverter to provide 480 VAC, 60 Hz output.
 - e. Inverter shall be housed in freestanding NEMA 1 enclosure with lockable cabinet doors and covers.
 - f. Inverter to have input voltage range of 300 VDC to 600 VDC.
 - g. Minimum CEC weighted efficiency of 95 percent.
 - h. Harmonic distortion of less than 3 percent.
 - i. Operating ambient temperature range of 32 deg. F. to 120 deg. F.
 - j. Inverter to be provided with load break rated AC output and DC input service disconnects.
 - k. Inverter to be provided with 10 year warranty.
6. Microprocessor Based Metering Equipment:
- a. Meters shall be integrated with inverter or in standalone enclosure.
 - b. Equipment device shall consist of a single microprocessor based unit capable of monitoring and displaying functions listed below at each inverter output.
 - c. Device shall provide local metering functions indicated and step-display buttons for selecting metering function to be displayed. Device shall have a

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communication port capable of enabling connection to remote performance monitoring and reporting service (PMRS). Metering equipment to include webserver and connection to GSA LAN in accordance with GSA IT policies.

d. Ambient Conditions: Device shall operate in following ambient conditions:

- 1) Temperature: 32 deg. F. to 120 deg. F.
- 2) Humidity: 95 percent non-condensing

e. Minimum Metering Functions: Direct reading metered or calculated values of items listed shall be displayed on a six-digit LED or LCD display screen with minimum accuracy requirements as follows:

- 1) AC amperes in each phase, 1 percent accuracy
- 2) AC voltage, phase-to-phase, phase-to-neutral, 1 percent accuracy
- 3) Kilo/watts 2 percent accuracy
- 4) Kilo/vars 2 percent accuracy
- 5) Power factor 4 percent accuracy
- 6) Frequency 1/2 percent accuracy
- 7) Kilo/watt demand 2 percent accuracy
- 8) Kilo/watt hours (Totalized) 2 percent accuracy

f. Display Screen: Digital display screen LEDs or LCD shall indicate value of amps, volts, watts, vars, P.F., and frequency. Device shall also signify reverse power flow, negative power factor, and negative kVAR. Unit shall trip in event of internal malfunction.

g. Operating Characteristics: Control power shall be drawn from monitored incoming AC line terminal connections. Device shall have non-volatile memory and not require battery backup. In event of power failure, device shall retain preset parameters. Device shall allow user to disable undesired values/functions and to later reactivate them if required. Neutral terminal shall be provided for four-wire, grounded systems.

h. Network Data Communication: Provide an addressable communication card capable of transmitting all data over a two-wire local area network (LAN) to a central computer for storage and/or printout. Network shall also be capable of transmitting data in RS232c format via a translator module.

D. Manufacturers:

1. Photovoltaic tiles, meeting the above specification, shall be manufactured by Sunpower, Sharp Electronics, or approved equal.
2. Photovoltaic panels, meeting the above specification, shall be manufactured by Sunpower, Sharp Electronics, or approved equal.
3. Wind turbines, meeting the above specification, shall be manufactured by Aerotecture, Wepower, Windspire, or approved equal.
4. Inverter, meeting the above specification, shall be manufactured by PV Powered, Solectria, or approved equal.

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5. Meters, meeting the above specifications, shall be manufactured by Square-D (Power Logic), Electro Industries/Gauge Tech, Veris Industries, Eaton Corp., or approved equal.

PART 3 - EXECUTION

3.1 PACKAGED WIND/PV SYSTEM INSTALLATION

- A. Contractor shall provide all wire and conduit for power, control and monitoring between all equipment and components of the complete system. Manufacturer or supplier shall provide all necessary wiring diagram indicating wire and conduit sizes and type.
- B. Field Quality Control: The following inspections and test procedures shall be performed by PV system manufacturer's factory-trained field service personnel during the startup for each PV system and equipment provided under this section.
 1. Before starting any PV system testing:
 - a. Check that non-current carrying metal parts are grounded properly. (array frames, racks, metal boxes, etc. are connected to the grounding system)
 - b. Ensure that all labels and safety signs specified in the plans are in place.
 - c. Verify that all disconnect switches (from the main AC disconnect all the way through to the combiner fuse switches) are in the open position and tag each box with a warning sign to signify that work on the PV system is in progress.
 2. PV Array--General:
 - a. Verify that all combiner fuses are removed and that no voltage is present at the output of the combiner box.
 - b. Visually inspect any plug and receptacle connectors between the modules and panels to ensure they are fully engaged.
 - c. Check that strain reliefs/cable clamps are properly installed on all cables and cords by pulling on cables to verify.
 - d. Check to make sure all panels are attached properly to their mounting brackets and nothing catches the eye as being abnormal or misaligned.
 - e. Visually inspect the array for cracked modules.
 - f. Check to see that all wiring is neat and well supported.
 3. PV Array Circuit Wiring:
 - a. Check home run wires (from PV modules to combiner box) at DC string combiner box to ensure there is no voltage on them.
 - b. Recheck that fuses are removed and all switches are open.
 - c. Connect the home run wires to the DC string combiner box terminals in the proper order and make sure labeling is clearly visible.
 - d. Check open-circuit voltage of each of the panels in the string being wired to verify that it provides the manufacturer's specified voltage in full sun. (Panels under the

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same sunlight conditions should have similar voltages--beware of a 20 Volt or more shift under the same sunlight conditions.)

- e. Verify that the both the positive and negative string connectors are identified properly with permanent wire marking.
- f. Repeat this sequence for all source circuit strings.
- g. Recheck that DC Disconnect switch is open and tag is still intact.
- h. Verify polarity of each source circuit string in the DC String Combiner Box (place common lead on the negative grounding block and the positive on each string connection--pay particular attention to make sure there is NEVER a negative measurement). Verify open-circuit voltage is within proper range according to manufacturer's installation manual and number each string and note string position on as-built drawing. (Voltages should match closely if sunlight is consistent.)
WARNING: If polarity of one source circuit string is reversed, this can start a fire in the fuse block resulting in the destruction of the combiner box and possibly adjacent equipment. Reverse polarity on an inverter can also cause damage that is not covered under the equipment warranty.
- i. Retighten all terminals in the DC String Combiner Box.
- j. Verify that the only place where the AC neutral is grounded is at the main service panel.
- k. Check the AC line voltage at main AC disconnect is within proper limits.
- l. If installation contains additional AC disconnect switches repeat the steps voltage check on each switch working from the main service entrance to the inverter AC disconnect switch closing each switch after the test is made except for the final switch before the inverter (it is possible that the system only has a single AC switch).

4. Inverter Startup Tests:

- a. Be sure that the inverter is off before proceeding with this section.
- b. Test the continuity of all DC fuses to be installed in the DC string combiner box, install all string fuses, and close fused switches in combiner box.
- c. Check open circuit voltage at DC disconnect switch to ensure it is within proper limits according to the manufacturer's installation manual.
- d. If installation contains additional DC disconnect switches repeat the step 4 voltage check on each switch working from the PV array to the inverter DC disconnect switch closing each switch after the test is made except for the final switch before the inverter (it is possible that the system only has a single DC switch).
- e. At this point consult the inverter manual and follow proper startup procedure (all power to the inverter should be off at this time).
- f. Confirm that the inverter is operating and record the DC operating voltage.
- g. Confirm that the operating voltage is within proper limits according to the manufacturer's installation manual.
- h. After recording the operating voltage at the inverter close any open boxes related to the inverter system.
- i. Confirm that the inverter is producing the expected power output on the supplied meter.
- j. Provide the Owner with the initial startup test report.

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5. System Acceptance Test:

- a. Check to make sure that the PV array is in full sun with no shading whatsoever. If it is impossible to find a time during the day when the whole array is in full sun, only that portion that is in full sun will be able to be accepted.
- b. If the system is not operating, turn the system on and allow it to run for 15 minutes before taking any performance measurements.
- c. Obtain solar irradiance measurement by one of two methods and record irradiance: W/m^2 . To obtain percentage of peak sun, divide irradiance by 1000 W/m^2 and record. (Example: $692 \text{ W/m}^2 \div 1000 \text{ W/m}^2 = 0.692$ or 69.2%.)

Method 1: Take measurement from calibrated solar meter or pyranometer.

Method 2: Place a single, properly operating PV module, of the same model found in the array, in full sun in the exact same orientation as the array being tested. After 15 minutes of full exposure, test the short circuit current with a digital multimeter and place that reading on this line: Amps. Divide this number into the short circuit current (I_{sc}) value printed on the back of the PV module and multiply this number by 1000 W/m^2 and record the value on the line above. (Example: $I_{sc}\text{-measured} = 3.6 \text{ Amps}$; $I_{sc}\text{-printed on module} = 5.2 \text{ Amps}$; $\text{Irradiance} = 3.6 \text{ Amps} / 5.2 \text{ Amps} * 1000 \text{ W/m}^2 = 692 \text{ W/m}^2$)

- d. Sum the total of the module ratings and record as $\text{Watts}_{\text{STC}}$. Multiply this number by 0.7 to obtain expected peak AC output and record on this line $\text{Watts}_{\text{AC-estimated}}$.
- e. Record AC Watt output from the inverter or system meter as $\text{Watts}_{\text{AC-measured}}$.
- f. Divide $\text{Watts}_{\text{AC-measured}}$ by percent peak irradiance and record as $\text{Watts}_{\text{AC-corrected}}$. This "AC-corrected" value is the rated output of PV system. This number must be within 90% or higher of $\text{Watts}_{\text{AC-estimated}}$ recorded in Step d. If it is less than 90%, the PV system is either shaded, dirty, miswired, fuses are blown, or the modules or inverter are not operating properly.

- C. Site Acceptance Testing: Site Acceptance Testing shall be provided by the manufacturer's field service personnel. The Contractor shall notify the Owner one month in advance of the Acceptance Test date for each PV system. Site testing shall consist of a complete test of the PV system and the associated accessories provided by the Contractor. A full load power test shall be provided as part of the Acceptance Testing. This shall be accomplished utilizing a temporary load bank. The test results shall be documented, signed, and dated for future reference. The Contractor shall promptly remove the temporary load bank upon satisfactory completion of Acceptance Testing.

END OF SECTION 263100

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SECTION 263100 - SOLAR WIND/PV SYSTEM

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL SYSTEM REQUIREMENTS

- A. This section is intended to cover Wind/PV systems and equipment and their installation applicable to the Contractor's work.
- B. Contractor shall include all labor, and material for the complete electrical work as specified, indicated and required for complete and proper performance of material, equipment and systems.
- C. Contract drawings and specifications are complementary each to the other, and what is called for by one shall be as binding as if called for by both.
- D. Equipment Storage and Protection: In general, equipment shall be stored in sheltered clean, dry area. If equipment must be stored in cool, damp areas, heaters shall be provided to keep equipment dry. Contractor shall protect special system equipment from moisture until final acceptance by Owner. Rusted areas on equipment enclosure shall be cleaned, prime painted and receive appropriate finish coat. Equipment or components of equipment receiving moisture or water damage shall be replaced with new equipment or components at Contractor's expense. Until final observation equipment bus bars, terminals and other internal components shall be protected by Contractor from paint, plaster, cleaners, abrasives, dust and spray by providing appropriate covers.
- E. Seismic Requirements: Wind/PV equipment shall be installed to prevent lateral movement and uplifting due to seismic forces. Seismic anchors shall meet the requirements in Section 262400 - VIBRATION AND SEISMIC CONTROL.
- F. Guarantee: Guarantee shall be as required in Section 260100, GUARANTEE article except as revised by specific articles on equipment specified in this section.
- G. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part number listed in this section articles are shown as basis of minimum standards and performance required. Should any equipment series, model or part numbers be obsolete or superseded, it shall be understood that newest equivalent series, model or part shall be furnished.

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H. Manufacturer's Field Service:

1. Service Personnel: The Wind/PV manufacturer shall directly employ a nationwide service organization, consisting of factory-trained field service personnel dedicated to the startup and maintenance of Wind/PV systems with their associated equipment and controls. The manufacturer shall provide a national dispatch center to coordinate field service personnel schedules. One toll-free number shall reach a qualified support person 24 hours/day, 7 days/week, 365 days/year.
2. Replacement Parts Stocking: Recommended spare parts shall be fully stocked by local field service personnel with back-up available from national parts center and the manufacturing location. The national parts center Customer Support Parts Coordinators shall be on-call 24 hours a day, 7 days a week, 365 days a year for immediate parts availability. Parts from the national parts center shall be shipped within 24 hours and delivered to the customer's site within 48 hours.
3. Wind/PV Maintenance Training: Maintenance training courses for the Owner's employees shall be provided by the Wind/PV manufacturer. This training is in addition to the basic operator training conducted as a part of the system startup.
 - a. The training course shall cover Wind/PV theory, location of subassemblies, safety, and operational procedures. The course shall include DC-to-AC inversion techniques as well as control and metering. Troubleshooting and fault isolation using alarm information and internal self-diagnostics shall be stressed.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and/or install and provide power for the following special systems equipment as indicated.
- B. Wind/PV Systems:
 1. Flat photovoltaic tiles
 2. Tilted photovoltaic panels
 3. Wind turbine
 4. Combiner box
 5. DC to AC inverter
 6. Metering equipment

1.4 DESCRIPTION OF SYSTEMS

- A. Following is general description of required Wind/PV systems equipment and devices:
 1. Wind/PV System: Wind/PV system shall be grid tied to the electrical utility grid system with existing building electrical distribution system and disconnect from distribution system upon interruption of the utility power.

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1.5 SUBSTITUTIONS

- A. See Section 260100.
- B. Substitutions shall also meet any additional requirements specified in this section under PART 2 - PRODUCTS.
- C. Space Allocation: Both physical and working space allocation indicated for Wind/PV equipment is based on first-named manufacturer. In event physically larger equipment is furnished, Manufacturer shall be responsible for making detailed installation drawings of equipment in an organized manner to match the allocated space prior to shipping any equipment.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100. Shop drawing submittals shall include but not be limited to following:
 - 1. Wind/PV System:
 - a. Flat photovoltaic tiles with mounting hardware
 - b. Tilted photovoltaic panels with mounting hardware
 - c. Wind turbine with mounting hardware
 - d. System combiner box
 - e. DC to AC inverter
 - f. Metering equipment
 - g. Cables and connectors
 - h. Reference Article 2.1 Paragraph A.5. "Submittals" for additional details.

PART 2 - PRODUCTS

2.1 PACKAGED WIND/PV SYSTEM

- A. General:
 - 1. Summary: This specification defines the electrical and mechanical characteristics and requirements for a grid tied Wind/PV system.
 - 2. Standards: The Wind/PV shall be designed in accordance with the applicable sections of the current revision of the following documents. Where a conflict arises between these documents and statements made herein, the statements in this specification shall govern.
 - a. NETA-ATS
 - b. NFPA-70
 - c. UL 1703 - for flat plate photovoltaic modules and panels
 - d. UL 1741 - for inverters, converters and controllers
 - e. IEEE 929 - recommended practice for utility interface of PV systems
 - f. IEEE 1262

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- g. IEEE 1547
- 3. System Description:
 - a. Design Requirements - Wind/PV System:
 - 1) Voltage: Output voltage specifications of the Wind/PV shall be 277/480 volts, 3 phase, four-wire-plus-ground.
 - 2) Output Load Capacity: Specified output load capacity of the Wind/PV shall be as indicated on Bid Submittal for each Option and Base Bid.
 - b. Modes of Operation: The Wind/PV shall be designed to operate as an electrical utility grid tie system to reduce the electrical utility demand of the building.
 - 1) Normal: The AC load is continuously supplied by the Wind/PV inverter. The Wind/PV system supplies DC power to the inverter which supplies AC power to existing electrical distribution system.
 - 2) Utility Outage: Upon failure of utility AC power, the AC load supplied by the inverter is to be disconnected to interrupt power to the building until restoration of the utility AC source.
- 4. Environmental Conditions: The Wind/PV shall be able to withstand the following environmental conditions without damage or degradation of operating characteristics:
 - a. Operating Ambient Temperature:
 - 1) Wind/PV Module: -20 deg. F. to 120 deg. F.
 - 2) Inverter: 32 deg. F. to 120 deg. F.
 - b. Relative Humidity: 0 to 95 percent, non-condensing.
 - c. Altitude:
 - 1) Operating: To 6600 ft. (2,000 M) above Mean Sea Level.
 - 2) Storage/Transport: To 40,000 ft. (12,200 M) above Mean Sea Level.
- 5. Submittals: Submittals shall include:
 - a. System configuration with single-line diagrams.
 - b. Functional relationship of equipment including weights, dimensions, and heat dissipation.
 - c. Descriptions of equipment to be furnished, including deviations from these specifications.
 - d. Size and weight of shipping units to be handled by Installing Contractor.
 - e. Detailed layouts of power and control connections.
 - f. Detailed installation drawings including all terminal locations.
 - g. Distribution cabinet details on size, quantity and type circuit breakers.

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- h. Submittals upon Wind/PV system delivery shall include:
 - 1) A complete set of submittal drawings.
 - 2) One instruction manual that shall include a functional description of the equipment with block diagrams, safety precautions, instructions, step-by-step operating procedures and routine maintenance guidelines, including illustrations.
- 6. Warranty: The Wind/PV system manufacturer shall warrant the system against defects in materials and workmanship for 12 months after the date of Substantial Completion of the work under this contract. Starting date for the warranty shall be the date of Substantial Completion of the work under this contract.
- 7. Quality Assurance:
 - a. Manufacturer Qualifications: A minimum of 5 years experience in the design, manufacture, and testing of Wind/PV systems is required. The system shall be designed and manufactured according to world class quality standards. The manufacturer shall be ISO 9001 certified.
 - b. Factory Testing: Before shipment, the manufacturer shall fully and completely test the system to assure compliance with the specification. These tests shall include operational discharge and recharge tests on at least a 1 minute battery plant to assure guaranteed rated performance.
 - c. Installer Qualifications: The installer of the Wind/PV systems shall have installed a minimum of 5 similar systems and be trained and approved by the Wind/PV system manufacturer.

B. Fabrication:

- 1. Materials: All materials of the Wind/PV system shall be new, of current manufacture, high grade and free from all defects and shall not have been in prior service except as required during factory testing.
- 2. Wiring: Wiring practices, materials and coding shall be in accordance with the requirements of the National Electrical Code (NFPA 70). All bolted connections of bus bars, lugs, and cables shall be in accordance with requirements of the National Electrical Code (NEC) and other applicable standards. All electrical power connections are to be torqued to the required value and marked with a visual indicator. Provision shall be made for power cables to enter or leave from the top or bottom of the Wind/PV cabinet.
- 3. Grounding: The AC output neutral shall be electrically isolated from the Wind/PV chassis. The Wind/PV chassis shall have an equipment ground terminal. Provisions for local bonding shall be provided.

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C. Components:

1. Flat Photovoltaic Roof Tile System:

- a. System to lay flat on existing roof in areas indicated on drawings as required to allow window washing support equipment cables to be routed on system from window washing support system to roof perimeter.
- b. System to allow for unobstructed roof drainage to existing roof drains and not interfere with roof operation or maintenance.
- c. System to include interlocking hardware to secure modules without roof attachments. If roof attachments or penetrations are required they are to be provided and sealed in accordance with existing roof manufacturer's requirements to maintain existing roof warranty.
- d. System components are to be corrosion resistant.
- e. System to weigh less than 5lb/ft².
- f. System to have a wind resistance of 140 mph.
- g. System to provide minimum of 15 peak Watts/ft².
- h. System to have temperate rating of -40 deg. F. to 185 deg. F. (-40 deg. C. to 85 deg. C.)
- i. System to have impact resistance of 1 inch hail at 52 mph (23 m/s)
- j. System to resist front and back wind load of 50 psf (24.5 kg/m²)
- k. System to be provided with 20 year warranty.

2. Tilted Photovoltaic Panel System:

- a. System to include photovoltaic panels mounted at a 10 degree tilt to increase system efficiency in areas designated on drawings.
- b. System to allow for unobstructed roof drainage to existing roof drains and not interfere with roof operation or maintenance.
- c. System to include interlocking hardware to secure modules without roof attachments. If roof attachments or penetrations are required they are to be provided and sealed in accordance with existing roof manufacturer's requirements to maintain existing roof warranty.
- d. System components are to be corrosion resistant.
- e. System to weigh less than 5lb/ft².
- f. System to have a wind resistance of 140 mph.
- g. System to provide minimum of 15 peak Watts/ft².
- h. System to have temperate rating of -40 deg. F. to 185 deg. F. (-40 deg. C. to 85 deg. C.)
- i. System to have impact resistance of 1 inch hail at 52 mph (23 m/s)
- j. System to resist front and back wind load of 50 psf (24.5 kg/m²)
- k. System to be provided with 20 year warranty.

3. Wind Turbine System:

- a. System to include three (3) vertical axis wind turbines rated for minimum of 2kW each.

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- b. System to be installed on three (3) structural elevator/stairwell penthouses as shown on drawings.
 - c. System to allow access to window washer tie-off system and unobstructed roof drainage off each penthouse.
 - d. System to include support components and to be attached to penthouse roof structure as required in accordance with manufacturer. All roof penetrations are to be sealed as required by existing roof manufacturer to maintain existing warranty.
 - e. All system components are to be corrosion resistant.
 - f. Each penthouse wind turbine with supports to weight less than 200 lbs.
 - g. System to be rated for wind speeds up to 90 mph.
 - h. System to have temperature rating of -40 deg. F. to 185 deg. F. (-40 deg. C. to 85 deg. C.)
 - i. System to have impact resistance of 1 inch hail at 52 mph (23 m/s)
 - j. System to be provided with 10 year warranty.
4. DC Combiner Box:
- a. Each Wind/PV system to be provided with separate DC power combiner box with overcurrent protection and disconnect rated at 600 VDC for each string of system.
 - b. Each combiner box to be provided with surge arrest device.
5. Inverter:
- a. Each inverter shall be certified to UL 1741 Standards by a Nationally Recognized Testing Laboratory (NRTL).
 - b. Each wind and PV system to be provided with separate inverter dedicated to system.
 - c. Each inverter to be sized to support 125 percent of the rated kW output of wind turbines or photovoltaic panels in system.
 - d. Each inverter to provide 480 VAC, 60 Hz output.
 - e. Inverter shall be housed in freestanding NEMA 1 enclosure with lockable cabinet doors and covers.
 - f. Inverter to have input voltage range of 300 VDC to 600 VDC.
 - g. Minimum CEC weighted efficiency of 95 percent.
 - h. Harmonic distortion of less than 3 percent.
 - i. Operating ambient temperature range of 32 deg. F. to 120 deg. F.
 - j. Inverter to be provided with load break rated AC output and DC input service disconnects.
 - k. Inverter to be provided with 10 year warranty.
6. Microprocessor Based Metering Equipment:
- a. Meters shall be integrated with inverter or in standalone enclosure.
 - b. Equipment device shall consist of a single microprocessor based unit capable of monitoring and displaying functions listed below at each inverter output.
 - c. Device shall provide local metering functions indicated and step-display buttons for selecting metering function to be displayed. Device shall have a

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communication port capable of enabling connection to remote performance monitoring and reporting service (PMRS). Metering equipment to include webserver and connection to GSA LAN in accordance with GSA IT policies.

d. Ambient Conditions: Device shall operate in following ambient conditions:

- 1) Temperature: 32 deg. F. to 120 deg. F.
- 2) Humidity: 95 percent non-condensing

e. Minimum Metering Functions: Direct reading metered or calculated values of items listed shall be displayed on a six-digit LED or LCD display screen with minimum accuracy requirements as follows:

- 1) AC amperes in each phase, 1 percent accuracy
- 2) AC voltage, phase-to-phase, phase-to-neutral, 1 percent accuracy
- 3) Kilo/watts 2 percent accuracy
- 4) Kilo/vars 2 percent accuracy
- 5) Power factor 4 percent accuracy
- 6) Frequency 1/2 percent accuracy
- 7) Kilo/watt demand 2 percent accuracy
- 8) Kilo/watt hours (Totalized) 2 percent accuracy

f. Display Screen: Digital display screen LEDs or LCD shall indicate value of amps, volts, watts, vars, P.F., and frequency. Device shall also signify reverse power flow, negative power factor, and negative kVAR. Unit shall trip in event of internal malfunction.

g. Operating Characteristics: Control power shall be drawn from monitored incoming AC line terminal connections. Device shall have non-volatile memory and not require battery backup. In event of power failure, device shall retain preset parameters. Device shall allow user to disable undesired values/functions and to later reactivate them if required. Neutral terminal shall be provided for four-wire, grounded systems.

h. Network Data Communication: Provide an addressable communication card capable of transmitting all data over a two-wire local area network (LAN) to a central computer for storage and/or printout. Network shall also be capable of transmitting data in RS232c format via a translator module.

D. Manufacturers:

1. Photovoltaic tiles, meeting the above specification, shall be manufactured by Sunpower, Sharp Electronics, or approved equal.
2. Photovoltaic panels, meeting the above specification, shall be manufactured by Sunpower, Sharp Electronics, or approved equal.
3. Wind turbines, meeting the above specification, shall be manufactured by Aerotecture, Wepower, Windspire, or approved equal.
4. Inverter, meeting the above specification, shall be manufactured by PV Powered, Solectria, or approved equal.

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5. Meters, meeting the above specifications, shall be manufactured by Square-D (Power Logic), Electro Industries/Gauge Tech, Veris Industries, Eaton Corp., or approved equal.

PART 3 - EXECUTION

3.1 PACKAGED WIND/PV SYSTEM INSTALLATION

- A. Contractor shall provide all wire and conduit for power, control and monitoring between all equipment and components of the complete system. Manufacturer or supplier shall provide all necessary wiring diagram indicating wire and conduit sizes and type.
- B. Field Quality Control: The following inspections and test procedures shall be performed by PV system manufacturer's factory-trained field service personnel during the startup for each PV system and equipment provided under this section.
 1. Before starting any PV system testing:
 - a. Check that non-current carrying metal parts are grounded properly. (array frames, racks, metal boxes, etc. are connected to the grounding system)
 - b. Ensure that all labels and safety signs specified in the plans are in place.
 - c. Verify that all disconnect switches (from the main AC disconnect all the way through to the combiner fuse switches) are in the open position and tag each box with a warning sign to signify that work on the PV system is in progress.
 2. PV Array--General:
 - a. Verify that all combiner fuses are removed and that no voltage is present at the output of the combiner box.
 - b. Visually inspect any plug and receptacle connectors between the modules and panels to ensure they are fully engaged.
 - c. Check that strain reliefs/cable clamps are properly installed on all cables and cords by pulling on cables to verify.
 - d. Check to make sure all panels are attached properly to their mounting brackets and nothing catches the eye as being abnormal or misaligned.
 - e. Visually inspect the array for cracked modules.
 - f. Check to see that all wiring is neat and well supported.
 3. PV Array Circuit Wiring:
 - a. Check home run wires (from PV modules to combiner box) at DC string combiner box to ensure there is no voltage on them.
 - b. Recheck that fuses are removed and all switches are open.
 - c. Connect the home run wires to the DC string combiner box terminals in the proper order and make sure labeling is clearly visible.
 - d. Check open-circuit voltage of each of the panels in the string being wired to verify that it provides the manufacturer's specified voltage in full sun. (Panels under the

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same sunlight conditions should have similar voltages--beware of a 20 Volt or more shift under the same sunlight conditions.)

- e. Verify that the both the positive and negative string connectors are identified properly with permanent wire marking.
- f. Repeat this sequence for all source circuit strings.
- g. Recheck that DC Disconnect switch is open and tag is still intact.
- h. Verify polarity of each source circuit string in the DC String Combiner Box (place common lead on the negative grounding block and the positive on each string connection--pay particular attention to make sure there is NEVER a negative measurement). Verify open-circuit voltage is within proper range according to manufacturer's installation manual and number each string and note string position on as-built drawing. (Voltages should match closely if sunlight is consistent.)
WARNING: If polarity of one source circuit string is reversed, this can start a fire in the fuse block resulting in the destruction of the combiner box and possibly adjacent equipment. Reverse polarity on an inverter can also cause damage that is not covered under the equipment warranty.
- i. Retighten all terminals in the DC String Combiner Box.
- j. Verify that the only place where the AC neutral is grounded is at the main service panel.
- k. Check the AC line voltage at main AC disconnect is within proper limits.
- l. If installation contains additional AC disconnect switches repeat the steps voltage check on each switch working from the main service entrance to the inverter AC disconnect switch closing each switch after the test is made except for the final switch before the inverter (it is possible that the system only has a single AC switch).

4. Inverter Startup Tests:

- a. Be sure that the inverter is off before proceeding with this section.
- b. Test the continuity of all DC fuses to be installed in the DC string combiner box, install all string fuses, and close fused switches in combiner box.
- c. Check open circuit voltage at DC disconnect switch to ensure it is within proper limits according to the manufacturer's installation manual.
- d. If installation contains additional DC disconnect switches repeat the step 4 voltage check on each switch working from the PV array to the inverter DC disconnect switch closing each switch after the test is made except for the final switch before the inverter (it is possible that the system only has a single DC switch).
- e. At this point consult the inverter manual and follow proper startup procedure (all power to the inverter should be off at this time).
- f. Confirm that the inverter is operating and record the DC operating voltage.
- g. Confirm that the operating voltage is within proper limits according to the manufacturer's installation manual.
- h. After recording the operating voltage at the inverter close any open boxes related to the inverter system.
- i. Confirm that the inverter is producing the expected power output on the supplied meter.
- j. Provide the Owner with the initial startup test report.

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5. System Acceptance Test:

- a. Check to make sure that the PV array is in full sun with no shading whatsoever. If it is impossible to find a time during the day when the whole array is in full sun, only that portion that is in full sun will be able to be accepted.
- b. If the system is not operating, turn the system on and allow it to run for 15 minutes before taking any performance measurements.
- c. Obtain solar irradiance measurement by one of two methods and record irradiance: W/m^2 . To obtain percentage of peak sun, divide irradiance by 1000 W/m^2 and record. (Example: $692 \text{ W/m}^2 \div 1000 \text{ W/m}^2 = 0.692$ or 69.2%.)

Method 1: Take measurement from calibrated solar meter or pyranometer.

Method 2: Place a single, properly operating PV module, of the same model found in the array, in full sun in the exact same orientation as the array being tested. After 15 minutes of full exposure, test the short circuit current with a digital multimeter and place that reading on this line: Amps. Divide this number into the short circuit current (I_{sc}) value printed on the back of the PV module and multiply this number by 1000 W/m^2 and record the value on the line above. (Example: $I_{sc}\text{-measured} = 3.6 \text{ Amps}$; $I_{sc}\text{-printed on module} = 5.2 \text{ Amps}$; $\text{Irradiance} = 3.6 \text{ Amps} / 5.2 \text{ Amps} * 1000 \text{ W/m}^2 = 692 \text{ W/m}^2$)

- d. Sum the total of the module ratings and record as $\text{Watts}_{\text{STC}}$. Multiply this number by 0.7 to obtain expected peak AC output and record on this line $\text{Watts}_{\text{AC-estimated}}$.
- e. Record AC Watt output from the inverter or system meter as $\text{Watts}_{\text{AC-measured}}$.
- f. Divide $\text{Watts}_{\text{AC-measured}}$ by percent peak irradiance and record as $\text{Watts}_{\text{AC-corrected}}$. This "AC-corrected" value is the rated output of PV system. This number must be within 90% or higher of $\text{Watts}_{\text{AC-estimated}}$ recorded in Step d. If it is less than 90%, the PV system is either shaded, dirty, miswired, fuses are blown, or the modules or inverter are not operating properly.

- C. Site Acceptance Testing: Site Acceptance Testing shall be provided by the manufacturer's field service personnel. The Contractor shall notify the Owner one month in advance of the Acceptance Test date for each PV system. Site testing shall consist of a complete test of the PV system and the associated accessories provided by the Contractor. A full load power test shall be provided as part of the Acceptance Testing. This shall be accomplished utilizing a temporary load bank. The test results shall be documented, signed, and dated for future reference. The Contractor shall promptly remove the temporary load bank upon satisfactory completion of Acceptance Testing.

END OF SECTION 263100

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SECTION 264000 - DISTRIBUTION (TO 600 VOLTS)

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS, and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL POWER DISTRIBUTION REQUIREMENTS

- A. This section is intended to cover distribution system(s) and equipment to 600 volts and their installation applicable to Contractor's work.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and as required for complete and proper performance of materials, equipment and systems.
- C. Equipment shall conform to the latest revised applicable NEMA and ANSI standards.
- D. Contractor shall receive, handle, store, install, and assemble equipment specified in accordance with manufacturer's instructions and recommendations. One copy of these instructions shall be included with equipment at time of shipment.
- E. Equipment Storage and Protection:
 - 1. In general, distribution equipment shall be stored in sheltered, clean, dry area. If equipment must be stored in cool or damp areas, heaters shall be provided to keep equipment dry. Contractor shall protect distribution equipment from moisture until final acceptance by Owner. Rusted areas on equipment enclosures shall be cleaned, prime painted and receive appropriate finish coat. Equipment or components of equipment receiving moisture or water damage shall be replaced with new equipment or components at Contractor's expense.
 - 2. Until final observation equipment bus bars, terminals and other internal components shall be protected by Contractor from paint, plaster, cleaners, abrasives, dust and spray by providing appropriate covers.
- F. Identification: Equipment and components shall be identified in accordance with Section 261950 - ELECTRICAL IDENTIFICATION.
- G. Type Connectors: Feeders to 600 volts terminated on bus bars within distribution equipment shall be made with either factory-installed lugs listed by UL for minimum of 167 deg. F. as part of the assembly or field-installed connectors. All connectors used shall be the same type and by

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the same manufacturer. Low voltage field-installed lugs shall be as specified in Section 261200, WIRE CONNECTIONS AND DEVICES (TO 600 VOLTS) article.

- H. Space Requirements: Contractor shall be responsible for determining both physical and working space requirements for equipment by manufacturers other than that of first-named manufacturer or manufacturer on which drawings were based.
- I. Service Disconnect Identification: Reference Section 261950 for nameplate specifications.
- J. Concrete Housekeeping Pads: Concrete pads shall be provided in accordance with the requirements in Section 260500, CONCRETE WORK article.
- K. Seismic Requirements:
 - 1. Equipment shall be installed to prevent lateral movement and uplifting of equipment under Seismic Zone 2 conditions.
 - 2. Reference appropriate equipment articles this section and section 262400 - VIBRATION AND SEISMIC CONTROL article for additional details.
- L. Equipment Series, Model or Part Numbers: Manufacturer's equipment series, model or part numbers listed in this section are shown as basis for minimum standards and performance required. Should any equipment series, model or part numbers be obsolete or superseded, it shall be understood that the newest equivalent series, model or part shall be furnished.
- M. Options: Reference Section 260000 for Options.
- N. New Circuit Breakers: Circuit breakers shall be new and not be reconditioned, rebuilt or remanufactured type. Manufacturer and supplier shall ensure that breakers can be traced to their original manufacturer.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install following 600 volt distribution equipment:
 - 1. Disconnect switches
 - 2. Fuses (to 600 volts)
 - 3. SPD

1.4 DESCRIPTION OF SYSTEMS

- A. Following is general description of the required power distribution equipment and devices:
 - 1. Panelboards: Panelboards will be circuit breaker type to provide distribution, disconnection and overcurrent protection of Wind/PV system output wiring.
 - 2. Existing Switchgear, Panelboards: Provide new circuit breakers or new switches with fuses for fusible distribution and overcurrent protection of new wiring as indicated.
 - 3. Disconnects: Provide loose mounted fusible disconnect switches.

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4. Surge Protective Device (SPD): Provide surge protective device to help protect the electrical system from effects of lightning induced currents.

1.5 SUBSTITUTIONS

- A. See Section 260100.
- B. Space Allocation: Both physical and working space allocation indicated for equipment to 600 volts is based on first-named manufacturer. In event physically larger equipment is furnished, Manufacturer and Contractor shall be responsible for making detailed installation drawings of equipment in an organized manner to match the allocated space prior to shipping any equipment.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100. Shop drawing submittals shall include but not be limited to the following:
 1. Disconnect switches
 2. Fuses (to 600 volts)
 3. Nameplates
 4. Surge protective device (SPD)
 5. Time Current Curves: Manufacturer shall supply time current curves for all circuit breakers and fuses used on job with shop drawings. Both breaker and fuse curves shall be on same size of transparent standard time, current, log paper to allow overlays.

1.7 ELECTRIC SERVICE DESCRIPTION

- A. General Description: Electric service will be provided from existing building.

1.8 BUILDING SYSTEM VOLTAGES

- A. Main Power Distribution: Existing 600 volt distribution for the building is 277/480 volt, 3 phase, four-wire, grounded wye.
- B. Miscellaneous lighting and power is 120/208 volt, 3 phase, four-wire, grounded wye provided by existing step-down transformers distributed through panelboards.

1.9 GROUNDING AND BONDING SYSTEMS

- A. General: Grounding and bonding of electrical system and equipment shall be provided in accordance with NEC.
- B. Grounding and Bonding: Reference Section 264500 - GROUNDING AND BONDING for additional details on grounding of equipment to 600 volts.

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PART 2 - PRODUCTS

2.1 DISCONNECT SWITCHES

A. General:

1. Disconnect switches for motor and power loads shall be furnished by the Contractor unless otherwise noted. Switches shall be rated 240 VAC or 600 VAC for appropriate circuits.
2. Switch doors shall have provisions for padlocking closed. Switch operating handle shall have provisions for padlocking in OFF position. Safety switches shall have interlock to prevent unauthorized opening of switch door while switch is ON. Provision for defeating interlock for authorized inspection shall be provided.
3. Codes and Standards: Switches shall meet NEC for wire bending space. Switches for motors shall meet NEC.
4. Auxiliary Contacts: Disconnect switches shall be provided with auxiliary contacts, where they are required to disconnect control circuits having a power source different than motor or power load being switched.
5. Switches mounted indoors shall have NEMA 1 enclosures.
6. Switches mounted outdoors on roofs for fan disconnects shall have NEMA 3R, non-ventilated, raintight enclosures.

B. Materials and Applications:

1. Three Phase 240 or 600 Volt Motor or Power Loads (Three-Pole Safety Switches):
 - a. 30 Through 1200 Amps: Disconnect switches for 3 phase motor or power loads shall be three-pole, quick-make, quick-break, heavy duty type, 80 percent rated, "safety switches", horsepower rated and UL listed. Switches shall have 167 deg. F. lugs and be rated for 240 VAC or 600 VAC as appropriate. Fused disconnect switches shall have 100,000 amperes RMS symmetrical with stand rating and have Class L or Class J or R fuses.
 - b. Fusible and Non-Fusible: Switches 30-600 Amps shall normally be non-fused type; however, when indicated to be fusible, fuses shall be in accordance with Fuses (To 600 Volts) article.
2. Single Phase 240 Volt Motor or Power Loads (Two-Pole Safety Switches):
 - a. 30 Through 1200 Amps: Disconnect switches for single phase motor or power loads shall be two-pole, quick-make, quick-break, heavy duty type, 80 percent rated, "safety switches", horsepower rated and UL listed. Switches shall have 167 deg. F. lugs and be rated for 240 VAC.
 - b. Fusible and Non-Fusible: Switches 30 to 1200 amps shall normally be non-fused type; however, when specified, a fusible, fuses shall be in accordance with Fuses (To 600 Volts) article.

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3. Single Phase 120 Volt Motor Loads (Single-Pole Non-Fusible Toggle Switches):
 - a. Manual Controller Disconnect Switch: Manual controller toggle switches for single phase motor loads shall be non-fused type as follows:
 - 1) Single-pole, non-fusible, manual controller toggle switches for single phase 120 volt, maximum 1 horsepower motor loads use 20 amp horsepower rated switches.
 - 2) For larger horsepower motor loads or fusible disconnects, use disconnect switches as specified above for 3 phase motor loads.
 - 3) Switches shall be maintained AC toggle type without pilots and motor overloads.
 - 4) Surface-mounted switches shall have switch lockout cover plate.
4. Single Phase 240 Volt Motor Loads (Two-Pole Non-Fusible Toggle Switches):
 - a. Disconnect Switch: Disconnect switches for single phase motor loads shall be non-fused type as follows:
 - 1) Two-pole, non-fusible, toggle switches for single phase 240 volt, maximum 2 horsepower motor loads use horsepower rated switches.
 - 2) For larger horsepower motor loads or fusible disconnects, use disconnect switches as specified above for 3 phase motor loads.
 - 3) Switches shall be maintained AC toggle type without pilots unless otherwise indicated.
5. Single Phase 120 or 277 Volt System Power Loads (Single-Pole Non-Fusible Toggle Switches): Single-pole toggle switches for single phase power loads at maximum of 1000 watts for 120 volts and 4000 watts for 277 volts shall be appropriate 20 amp, single-pole, AC maintained contact toggle switches. Switches shall be without pilots unless otherwise indicated. Two-pole disconnects for larger single phase power loads use one of the disconnects as specified above.

C. Manufacturer:

1. Three Phase Motor and Power Loads:
 - a. 30 Through 1200 amps: Manufacturer of 600 VAC and 240 VAC Heavy Duty, three-pole safety switches shall be Square-D (Heavy Duty Class 3110), General Electric (Type TH), Siemens Energy and Auto. Inc. Type VBII (Heavy Duty), Eaton Corp. (Type DH), or approved equal.
2. Single Phase Motor or Power Loads: Manufacturer of 240 volt safety switches shall be Square-D, Eaton Corp., General Electric, Siemens Energy and Auto, Inc., or approved equal.

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3. Single Phase Motor Loads:
 - a. Manual Controller (No Overload Protection):
 - 1) Toggle switches rated for 120 volt motors shall be SPST rated at minimum 20 amps, 120/277 volt for single phase motors and be manufactured by Pass & Seymour PS20AC2-HP, Hubbell HBL3031, or approved equal.
 - 2) Toggle switches for 240 volt motors shall be DPST rated at minimum 20 amps, 277 volts for single phase motors and be manufactured by Pass & Seymour PS20AC2-HP, Hubbell HBL3032, or approved equal.
4. Single Phase Power Loads: Toggle switches for power loads shall be Pass & Seymour PS20AC1 or PS20AC2 series, or approved equal.

2.2 EXISTING LOW VOLTAGE (CIRCUIT BREAKER) SWITCHBOARDS

A. General:

1. This article describes existing low voltage, dead-front, freestanding, switchboard sections utilizing circuit breakers for switching and protection of feeders.
2. Submittals: The following information shall be submitted to the Architect/Engineer for approval prior to shipment.
 - a. Master submittal index
 - b. Schematic diagrams
 - c. Nameplate details
 - d. Component list including circuit breakers and details
 - e. Assembly ratings including:
 - 1) Short circuit rating
 - 2) Voltage
 - 3) Continuous current rating
 - f. Major component ratings including:
 - 1) Voltage
 - 2) Continuous current rating
 - 3) Interrupting ratings
 - g. Cable terminal sizes

B. Materials and Applications:

1. Hardware: Necessary bolting hardware shall be supplied.
2. Covers: Screwed-on front covers shall match existing switchboard.
3. Finish: Exterior and interior steel surfaces of new panels shall be properly cleaned and finished with ANSI enamel over rust-inhibiting primer to match existing.

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4. Molded Case Circuit Breakers:
 - a. General: Molded case circuit breakers shall be similar to existing.
 - b. Construction: Breakers shall provide circuit overcurrent protection by opening the breaker on sustained overload or short circuit conditions. Circuit breakers shall be operated by a toggle-type handle and shall have a quick-make, quick-break over-center switching mechanism. Automatic tripping of the breaker shall be clearly indicated by breaker handle position.
 - c. Molded case breakers shall have minimum 22,000 symmetrical rms interrupting capacity at 208 volts. Molded case breakers shall have minimum 22,000 symmetrical rms interrupting capacity at 480 volts. Verify correct A.I.C. prior to ordering.
5. Nameplates: Provide laminated nameplates with appropriate designations listed or as otherwise directed for each new circuit breaker, instrument and instrument switch. Nameplates shall be provided. Similar to existing to identify the load.
- C. Manufacturer: Circuit breaker switchboard components shall be manufactured by same manufacturer as the existing switchboard.

2.3 EXISTING LOW VOLTAGE (FUSIBLE) SWITCHBOARDS

A. General:

1. This article describes existing low voltage, dead front, freestanding, switchboard sections utilizing fusible switches for switching and protection of feeders.
2. Submittals: The following information shall be submitted to the Architect/Engineer for approval prior to shipment.
 - a. Master submittal index
 - b. Schematic diagrams
 - c. Nameplate details
 - d. Component list including fusible switches and details
 - e. Assembly ratings including:
 - 1) Short circuit rating
 - 2) Voltage
 - 3) Continuous current rating
 - f. Major component ratings including:
 - 1) Voltage
 - 2) Continuous current rating
 - 3) Interrupting ratings
 - g. Cable terminal sizes

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B. Material and Application:

1. Hardware: Necessary bolting hardware shall be supplied.
2. Covers: Screwed-on front covers shall match existing switchboard.
3. Finish: Exterior and interior steel surfaces of new panels shall be properly cleaned and finished with ANSI enamel over rust-inhibiting primer to match existing.
4. Fusible Switches QMQB Type (600 amp and below):
 - a. Quick-make, quick-break switches shall be used for all distribution switches unless otherwise indicated.
 - b. Ampere rating and fuse size shall be as indicated. Switch lugs shall be rated for min. 167 deg. F.
 - c. Switches shall have provision for padlocking in both open and closed positions.
 - d. Fusible switch units shall be individually enclosed equipped with deionizing grids and silver alloy contacts readily visible with switch door open for normal safety. Contacts shall have over-travel to compensate for normal wear and assure positive connections.
 - e. Fuse holders shall be of the high-pressure type using compression coil spring located out of heat zone. Fuse holders shall be same type as existing.
5. Fuses: Fuses shall be provided in accordance with drawings and Fuses (To 600 Volts) article.
6. Nameplates: Provide laminated nameplates with appropriate designations listed or as otherwise directed for each new fusible switch, instrument and instrument switch. Nameplates shall be provided. Similar to existing to identify the load.

- C. Manufacturer: Fusible switchboard components shall be manufactured by the same manufacturer as the existing switchboard.

2.4 PANELBOARDS (CIRCUIT BREAKER AND FUSIBLE SWITCH)

A. General:

1. This article covers construction of branch circuit panelboards and power panelboards.
2. Refer to one-line power diagram on drawings for specific requirements of each panelboard.
3. Codes and Standards:
 - a. Panelboards shall be furnished and installed to meet NEC. Panelboards and cabinets shall be UL listed and tested to latest revised UL Standard 67 and 50. Panelboards shall be manufactured in accordance with latest revised NEMA standards.
 - b. Panelboards shall be of the dead-front type and shall be in accordance with UL, Standard for Panelboards and Standard for Cabinets and Boxes and shall be so labeled. Panelboard circuit breakers shall be labeled for 167 deg. F. terminations.
 - c. Fully Rated: Short circuit rating of any circuit breaker must match or exceed the available short circuit current. Series rated breakers are not acceptable.

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B. Materials and Applications:

1. Gutter Space: Panelboards shall have gutter space top, bottom and sides to meet UL requirements. Panels requiring gutter taps or subfeed lugs shall have extra wide gutters. Gutters shall accommodate the connectors specified in General Power Distribution Requirements article of this section.
2. Doors, Keys and Locks: Each lighting and appliance panelboard shall have front trims with hinged doors and locks unless otherwise indicated. Power distribution panelboards in corridors or other locations accessible to other than maintenance personnel shall have doors with locks. Doors shall have catches and locks with keys.
3. Door-Mounted Directory: When panelboards have doors, directory holder mounted inside of door shall be standard size with protective Lexan or clear plastic cover.
4. Indoor-Mounted Panels: Panelboard enclosures mounted inside the building shall be NEMA 1 and be fabricated with galvanized steel. Trims shall have the same ANSI gray enamel finish. Reference Panelboard Installation article for additional details prior to ordering panelboards. Trim shall have angle support along the inside bottom serving as support between trim and enclosure for safe installation and removal.
5. Assembly and Accessories:
 - a. Assembly: Panelboard interiors shall be factory-assembled complete with branch circuit devices as shown or scheduled. Main busing and enclosures of distribution and power panelboards shall be of such design that branch circuit protective devices may be changed without additional machining, drilling or tapping.
 - b. Phase Busing: Main busing shall be rectangular copper predrilled and tapped to exact pole centers. Main bus shall extend full vertical length of enclosure to allow for future installation of branch circuit devices in spaces or blanks.
 - c. Neutral Bus: Neutral bus shall be provided on 120/240 volt, 120/208 volt and 277/480 volt panelboards. Neutral bus shall be insulated from panelboard backcan, be copper and have an individual terminal for each grounded (neutral) conductor required in a branch circuit or feeder.
 - d. Equipment Ground Bus: Equipment grounding bus shall be provided where branch circuits and/or feeders to panelboards are indicated to have equipment grounding conductors. Equipment ground bus shall be grounded to panelboard backcan, be copper and have suitable terminals for each outgoing branch circuit or feeder requiring an equipment grounding conductor.
6. Panelboards (Circuit Breaker Type):
 - a. Circuit Breakers:
 - 1) Circuit breakers shall be individual unit construction complete with quick-make, quick-break mechanism, and thermal-magnetic trip and be of the indicating type, providing ON, OFF and TRIPPED positions of the operating handle.
 - 2) Multi-pole breakers shall consist of single molded case and be so designed that overload on one-pole automatically causes all poles to open. Handle

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- ties are only acceptable if circuit breakers have internal common trip mechanism.
- 3) Circuit breakers, unless otherwise noted, shall have min. 167 deg. F. lugs. Continuous ampere rating shall be in 104 deg. F. ambient.
 - 4) Circuit breakers shall be bolt-on type for positive contact with the bus bars.
 - 5) Main and branch circuit breakers shall be sized as indicated.
 - 6) Amp interrupting capacity for 60 Hertz circuit breakers shall be minimum of 10,000 AIC for 240 VAC or 14,000 AIC for 480 VAC unless otherwise indicated.
 - 7) Molded case circuit breakers shall meet latest revised UL 489 standard and be UL listed for installation in panelboard in which they are installed.
- b. Circuit breakers in 100 amp frame size with trips 40 amps and above shall have terminals rated for 167 deg. F.
 - c. Circuit breakers in 110 amp through 225 amp frame sizes shall be thermal-magnetic trip with inverse time current characteristics, unless otherwise noted.
 - d. DC Circuit Breakers: DC circuit breakers shall be UL listed for 5,000 AIC minimum at 48 VDC.
 - e. Current Limiting Molded Case Circuit Breakers:
 - 1) Breakers must meet UL 489 and have 200,000 AIC.
 - 2) Current-limiting breakers shall not incorporate a fusible element and shall when operating within its current limiting range limit the let-through IT to a value less than the IT of a 1/2 cycle wave of the available symmetrical short circuit current.
 - 3) Breakers shall have a minimum interrupting rating of 100,000 amps rms symmetrical at 240 volts or 480 volts.
 - 4) 100 amp frame breakers shall have fixed thermal-magnetic trips. 225 amp and 400 amp frame breakers shall have fixed thermal trip and adjustable magnetic trip elements.
7. Panelboard (Fusible Switch Type):
- a. Fusible switch units shall be individually enclosed, quick-make, quick-break, equipped with deionizing grids and silver alloy contacts readily visible with the switch door open for normal safety. Fusible switch lugs shall be rated for min. 167 deg. F. lugs.
 - b. Contacts shall have over-travel to compensate for normal wear and assure positive connections. Fuse holders shall be of high-pressure type using compression coil spring located out of heat zone.
 - c. Switches shall be provided with external operating handle which can be triple padlocked in either ON or OFF position.
 - d. A cover interlock shall prevent opening the door over the fuse compartment unless the switch is in OFF position. Provision for voiding interlock for authorized inspection shall be provided.
 - e. Fuses shall be provided as indicated. Reference specifications Fuses (To 600 Volts) article for fuse details.

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- f. Each switch shall have nameplate as specified in Section 261950 - ELECTRICAL IDENTIFICATION.

C. Manufacturer:

1. Panelboards shall be products of one manufacturer unless otherwise noted and shall be standard products of Eaton Corp., Square-D, General Electric, Siemens Energy & Auto. Inc., or approved equal.
2. Equipment shown on drawings and in specifications is based on standard products of Eaton Corp. Contractor shall be responsible for space requirements of other approved manufacturers.

PART 3 - EXECUTION

3.1 DISCONNECT SWITCH INSTALLATION

- A. Disconnect switches shall be provided in sight of the motor where the motor is out of sight from controller location and the controller disconnect cannot be locked in the "open" position.
- B. Switches shall be rigidly supported.
- C. Disconnect switches on exterior walls or outdoors shall be mounted on appropriate U-type channel galvanized steel framing members.

3.2 INSTALLATION OF LOW VOLTAGE CIRCUIT BREAKERS IN EXISTING SWITCHBOARDS

- A. Install circuit breakers where indicated.
- B. Circuit breakers shall be OPEN prior to making wiring connections. Install wire and cable taking care as to avoid possibility of future physical damage and overheating of cables. Phase conductors of feeder circuit shall be of same length. Do not exceed wire and cable manufacturer's bending radius at terminations.
- C. Cable lugs shall be of correct size and type to match the conductor and be tightened to manufacturer's recommended torque values.
- D. Before energizing the switchboard, Contractor shall perform visual inspection and perform 600 volt feeder insulation test.
- E. Operate all circuit breakers three (3) times manually under load. Circuit breakers failing to open and close shall be replaced at Contractor's expense.
- F. Nameplates: Refer to Section 261950 - ELECTRICAL IDENTIFICATION article for nameplate requirements.

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- G. Exposed finished sheet metal front, sides and back shall be cleaned and tape, stickers and other markings shall be removed. Nicks, scrapes and scratches shall be touched-up with paint to match finish prior to final observation.

3.3 INSTALLATION OF LOW VOLTAGE (FUSIBLE) SWITCHES IN EXISTING SWITCHBOARDS

- A. Install fusible switches and blank panels where indicated.
- B. Switches shall be OPEN prior to making wiring connections. Install wire and cable taking care as to avoid possibility of future physical damage and overheating of cables. Phase conductors of feeder circuit shall be of same length. Do not exceed wire and cable manufacturer's bending radius at terminations.
- C. Cable lugs shall be of correct size and type to match the conductor and be tightened to manufacturer's recommended torque values.
- D. Before energizing the switchboard, Contractor shall perform visual inspection and perform 600 volt feeder insulation test as specified in Section 260100, Testing article.
- E. Install fuses of appropriate type, size and voltage.
- F. Operate all switches three times manually under load. Switches failing to open and close shall be replaced at Contractor's expense.
- G. Nameplates: Refer to specification Section 261950 - ELECTRICAL IDENTIFICATION article for nameplate requirements.
- H. Exposed finished sheet metal front, sides and back shall be cleaned and tape, stickers and other markings shall be removed. Nicks, scrapes and scratches shall be touched-up with paint to match finish prior to final observation.

3.4 PANELBOARD (CIRCUIT BREAKER AND FUSIBLE SWITCH) INSTALLATION

- A. General:
 - 1. Wall-Mounted Panelboards: The new panelboards shall be mounted with the top of panelboard aligned with the top of existing panelboards located in the same area.
 - 2. Panelboard enclosures shall be mounted permanently and securely in place. Where multiple panelboards are installed, panelboard enclosures shall be positioned to allow panelboard trims to align at the top. Reference following paragraph for additional details.
 - 3. Run all conduits to panelboard enclosures to meet job requirements.
 - 4. Correct size of circuit breakers, fusible switches, etc., shall be mounted in place to match branch circuits indicated on the drawings.
 - 5. Run all circuit conductors in conduits and terminate on appropriate overcurrent protective device. Verify that all cable and wire connections are adequately torqued to provide good electrical contact free from overheating.

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6. Panelboard interiors shall be cleaned and all foreign matter removed. Decals, stickers, and other markings except panelboard nameplates shall be removed from panelboard exterior. Nicks, scrapes and scratches shall be touched-up with paint to match finish prior to final observation.
7. Panelboard trims shall meet flush with enclosure or wall without bowing.

B. Surface Mounted:

1. Panelboards in unfinished spaces shall be surface mounted.
2. Exterior Walls: Panelboards on building exterior walls shall be mounted on U-type channel framing members to provide minimum 1 inch air space between panel and wall. Refer to Section 261900 - ELECTRICAL EQUIPMENT SUPPORTING DEVICES article for additional requirements.
3. Interior Walls: Panelboards shall be secured to wall at a minimum of four (4) locations using appropriate type seismic anchors and vibration isolators.

C. Electrical Identification: Reference Section 261950 for additional details.

1. Panelboard Identification: Affix panelboard nameplate on the outside panelboard trim at the top. Type in description of correct load on panelboard directories located inside the panelboard on the door. Panelboard nameplate shall include two (2) lines of engraved lettering. On top line, engrave panelboard designation shown on Panelboard Schedule. On bottom line engrave voltage phase and wire description. Panelboard nameplate shall be centered on panelboard trim above door. Nameplate shall be fastened with two (2) stainless steel or nickel-plated screws.
2. Panelboard Directory: Fill out panelboard directory cards by typing in load description. Directories shall be updated and reflect those circuit numbers and load descriptions indicated on the Record Drawings.

END OF SECTION 264000

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DIVISION 26 – ELECTRICAL WORK

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SECTION 264500 - GROUNDING AND BONDING

PART 1 - GENERAL

1.1 REFERENCES

- A. All sections of Division 01, GENERAL REQUIREMENTS, and requirements of Section 260100 - BASIC ELECTRICAL REQUIREMENTS, govern work under this specification section.

1.2 GENERAL GROUNDING AND BONDING REQUIREMENTS

- A. This section is intended to cover the general grounding and bonding of electrical distribution system(s) and equipment and their installation applicable to Contractor's work.
- B. Contractor shall include all labor and material for complete electrical work as specified, indicated and as required for grounding and bonding.

1.3 SCOPE OF WORK

- A. Contractor shall furnish and install the following grounding and bonding equipment:
 - 1. Meter boxes grounding and bonding
 - 2. Separately derived AC system grounding electrodes
 - 3. Surge protective device (SPD)
 - 4. Metallic raceways and other enclosure grounding and bonding

1.4 DESCRIPTION OF SYSTEMS

- A. Following is general description of the required grounding and bonding equipment and devices:
 - 1. Existing Switchboard(s): The Contractor shall verify that the existing switchboard enclosures are grounded.
 - 2. Surge Protective Device (SPD): SPD shall be grounded to the switchboard or panelboard equipment ground bus in which it is located or protects.
 - 3. Existing Panelboards: The Contractor shall verify that the existing panelboard enclosures are grounded.
 - 4. Panelboards: The panelboards metallic enclosure and its equipment ground bus shall be grounded with an equipment grounding conductor and the conduit grounding network.
 - 5. Disconnects: Disconnect switches metallic enclosures shall be grounded with an equipment grounding conductor and the conduit grounding network.

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1.5 SUBSTITUTIONS

- A. See Section 260100.

1.6 SHOP DRAWINGS AND SUBMITTAL REQUIREMENTS

- A. See Section 260100.

PART 2 - PRODUCTS

2.1 GROUND CONDUCTORS

A. General:

1. UL and NEC listed types shall be copper.
2. Size: Size of conductors shall not be less than required by the NEC or Authority Having Jurisdiction (AHJ).
3. All feeders and branch circuit raceways shall have an equipment grounding conductor.

B. Grounding Conductors:

1. Insulated Type: Grounding conductors run with feeders and branch circuits shall have insulation as listed in Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS). Insulation of feeders and branch circuit grounding conductors up to size #6 AWG shall be green in color. Insulation of wire in sizes #4 AWG and larger are not normally available in green therefore they shall be identified with green tape.
2. Non-Insulated Type: Grounding conductors shall be in accordance with NEC.

- C. Grounded (Neutral) Conductors: Feeder and branch circuit neutral conductors for systems to 600 volts shall have insulation as listed in Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS).

2.2 GROUND CONNECTORS

A. General:

1. UL listed type and be rated for copper connections.
2. Ground connecting devices for a wire, cable or rebar shall match the diameter of the wire, cable or rebar. When connectors are to be connected to a bus they shall have appropriate NEMA mounting holes.
3. Ground connectors buried below grade shall be rated for direct burial.

- B. Mechanical Type: Mechanical connectors shall have Allen set screws and be rated for 194 deg. F.

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- C. Compression Type: Compression connectors shall be fastened with matching hydraulic tool and be rated for 194 deg. F.
- D. Welded Type: Welded connectors shall be exothermic type set in appropriate mold.

2.3 MANUFACTURERS

- A. The following manufacturers, or approved equal, of grounding and bonding products may be used. Specific items are indicated in brackets.
- B. Grounding Conductors:
 - 1. Bare:
 - a. Thompson Lightning Protection Inc.
 - b. Heary Brothers Lightning Protection Co.
 - c. Robbins Lightning, Inc.
 - d. ERICO Inc.; (Braid)
 - e. ILSCO (Braid)
 - 2. Insulated:
 - a. American Insulated Wire
 - b. Southwire Co.
 - c. Rome Cable Corp.
 - d. Prysmian Cables and Systems.
- C. Grounded (Neutral) Conductors:
 - 1. American Insulated Wire
 - 2. Southwire Co.
 - 3. Rome Cable Corp.
 - 4. Prysmian Cables and Systems.
- D. Ground Connectors:
 - 1. Thomas & Betts, Electrical (60100 and 60200 compression)
 - 2. Anderson (Pipe clamps, connectors, flexible copper braid)
 - 3. ERICO Inc. (Cadweld, welded type)
 - 4. Thermoweld (welded type)
 - 5. Furseweld (welded type)
 - 6. Harger Lightning Prot. Inc. (Ultraweld, welded type)
 - 7. Amp Products Corp. (wedge lock type)
 - 8. Ideal Industries, Inc.
 - 9. ILSCO Corp. (CRA-L and CRB-L compression) (TA and AU mechanical)
 - 10. Burndy (compression type)
 - 11. Greaves Corp. ("Jones Bond" or "High-Wing," mechanical type to rebars)

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12. Buchanan (Cytolek mechanical type)
13. Mar-Tek Ind. (Branch Circuit, Term-A-Nut)

PART 3 - EXECUTION

3.1 SEPARATELY DERIVED AC SYSTEM GROUNDING ELECTRODE

- A. Grounding electrode for separately derived AC systems shall be provided in accordance with NEC and be as practicable to and preferably in the same area as the grounding conductor connection to the system. The grounding electrode shall be the nearest one of the following:
 1. An effectively grounded structural metal member of the structure.
 2. An effectively grounded metal water pipe within 5 ft. from the point of entrance into the building.
 3. Made and other electrodes as specified in NEC. See the following BUILDING GROUNDING ELECTRODE SYSTEM article, where electrodes specified by A and B above are not available.

3.2 EQUIPMENT GROUNDING CONDUCTOR

- A. Equipment grounding conductors shall be used for grounding non-current carrying metallic parts of electrical equipment used on job listed in NEC and other equipment shown on the drawings. Equipment grounding conductors (copper wire, metallic conduit, cable tray etc.) shall be terminated on the equipment ground bus.
- B. Size: Equipment grounding conductors (copper wire) shall meet 2002 NEC Table 250.122 unless a larger size is indicated on the drawings.
- C. Material and Insulation: Grounding conductors shall be copper. Equipment grounding conductors shall have green insulation or green tape marking or be bare as required by the NEC. Reference Section 261200 - CONDUCTORS AND CABLES (TO 600 VOLTS) and Conductor Color Coding subparagraph for additional details of grounding conductors for systems to 600 volts.
- D. Raceway: Equipment grounding conductors shall be run inside the conduit or raceway with phase conductors or wires. Non-metallic conduits or raceways shall have grounding conductors.
- E. Parallel Phase and Equipment Ground Conductors in Multiple Raceways: Where parallel phase conductors No. 1/0 and larger are run in multiple raceways, the equipment grounding conductor, where used, shall be run in parallel in each raceway.
- F. Larger Equipment Grounding Conductors Due to Long Conduit Runs: Contractor shall verify the sizes of conduit shown on the drawings and increase their size where necessary to comply with the following:

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1. For metallic conduit runs 300 ft. and longer with 30 amp, 120 volt circuits using 1/2 inch or 3/4 inch conduit, the equipment grounding conductor shall be minimum #8 AWG to reduce the impedance to ground.
2. For metallic conduit runs 280 ft. and longer with 40 amp, 120 volt circuits using 3/4 inch conduit, the equipment grounding conductor shall be minimum #8 AWG to reduce the impedance to ground.

3.3 NEUTRAL BUS

- A. Neutral bus of each panelboard switchboard or switchgear shall be insulated from equipment enclosure and have provisions for terminating all of the branch circuit and feeder neutral (grounded) conductors.
- B. Neutral grounded bus for each building's secondary service or separately derived system shall be connected to the equipment grounding conductors in only one place. This shall be in the separately derived system's disconnecting means enclosure.

3.4 SHIELDED CABLE GROUNDING

- A. Auxiliary or Communications Cable: Auxiliary system cables with a foil, tube or braided metal wire shield used to prevent electrostatic or electromagnetic interference between the shielded conductors and its surrounding field shall be grounded. Shields shall be grounded in accordance with the auxiliary system manufacturer's wiring instructions.

3.5 METALLIC RACEWAYS AND OTHER ENCLOSURE GROUNDING AND BONDING

- A. Non-conductive paint, enamel or similar coating shall be removed at threads and contact surfaces. Metallic raceways shall be effectively bonded by mechanically securing to metallic enclosures, frames or structures to which they are attached to by listed fittings that provide good metal-to-metal contact. Bonding between raceways and enclosures shall provide effective electrical continuity with capacity to safely conduct fault current likely to be imposed on the bonding.
- B. Metallic raceways attached to metallic enclosures, frames and structures of substations, switchgear, switchboards, motor control centers, disconnect switches, panelboards or boxes shall be effectively bonded with listed fittings to provide good metal-to-metal contact.
- C. Metallic Covers or Wall Plates: Metallic covers, faceplates or wall plates for metallic conduit fittings, pull boxes, junction boxes, voice/data outlets, and power receptacle outlet boxes shall be grounded by tightening all available metallic screws.
- D. Bonding Over 250 Volts: Rigid and IMC conduits installed between metallic enclosures with circuits over 250 volts to ground shall have threaded couplings to maintain the bonding between the enclosures and the rigid steel or IMC raceways.

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3.6 WIRING DEVICE GROUNDING

A. In Metal Boxes:

1. **Wiring Device Grounding:** Power receptacles and wall switches shall have self-grounding feature via metal grounding clip or metal mounting screw as specified. Clip shall ensure ground continuity between wiring device's metal mounting strap or yoke and the metal wall box. Receptacles having a grounding screw shall be grounded with an equipment grounding conductor terminated on the ground screw.
2. **Cover Mounted Receptacles:** For cover mounted power receptacles located on surface-mounted metallic boxes, electrical continuity shall be provided by an equipment bonding jumper between the grounded outlet box and the receptacle's grounding terminal.
3. **Box Mounted Receptacles:** For box mounted power receptacles located on surface or flush-mounted metallic boxes, electrical continuity shall be provided by the supporting screws used to fasten the receptacle's device yoke to the grounded outlet box and by a grounding conductor fastened to the ground screw on the receptacle.

B. In Non-Metallic Boxes:

1. **Wiring Device Grounding:** Power receptacles, wall switches and dimmers shall have an equipment grounding conductor or bonding jumper terminate on the power receptacle, wall switch or dimmer.
2. **Cover Mounted Receptacles:** For cover mounted power receptacles located on surface-mounted non-metallic boxes, electrical continuity shall be provided by an equipment bonding jumper between the equipment grounding conductor in the outlet box and the receptacle's grounding terminal.

END OF SECTION 264500

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SUBMITTAL REGISTER

Title and Location						CONTRACT NUMBER: GS06P04GYD00				PROJECT NUMBER: RMO00090					
GSA - RAY ARRA Mech - Wind/PV Package															
						CONTRACTOR SCHEDULE DATES				CONTRACTOR ACTION		GOVERNMENT ACTION			
Acct #	SPEC #	SPEC. NAME	Trans #	Item #	SUBMITTAL DESCRIPTION, TYPE, CLASSIFICATION & PARAGRAPH NO.	Rev'er	SUBMIT	APPROV NEEDED BY	MATERIAL NEEDED BY	C O D E	DATE	SUBMIT TO GOV.	C O D E	DATE	REMARKS
	260100	BASIC ELECTRICAL REQUIREMENTS		1.20	Record Drawings										
				1.21	Maintenance Manuals										
				1.24	Testing										
				1.26	Submittal Summary										
	260500	BASIC ELECTRICAL MATERIALS AND METHODS		1.6	Product Data										
	261200	CONDUCTORS AND CABLES (TO 600 VOLTS)		1.6	Product Data										
	261300	RACEWAYS AND BOXES		1.5	Product Data										
	261900	ELECTRICAL EQUIPMENT SUPPORTING DEVICES		1.6	Product Data										
	261950	ELECTRICAL IDENTIFICATION		1.6	Product Data										
	262400	VIBRATION AND SEISMIC CONTROL		1.8	Seismic Calculations										
				1.8	Product Data										
	263100	WIND/PV SYSTEM		1.6	Product Data										

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	264000	DISTRIBUTION (TO 600 VOLTS)		1.6	Product Data											
	264500	GROUNDING AND BONDING		1.6	Product Data											

Codes: (use all that apply)

R - Reviewed

NR - Note Reviewed

S - Submit Corrected Copies

RN - Reviewed as Noted

RR - Revised and Resubmit

C - Comments Attached